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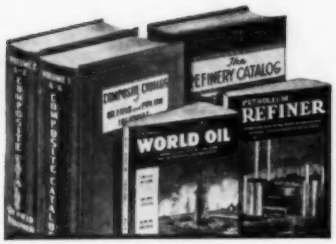

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Why Petroleum Refiner
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VOLUME 28, NO. 1 JANUARY, 1949

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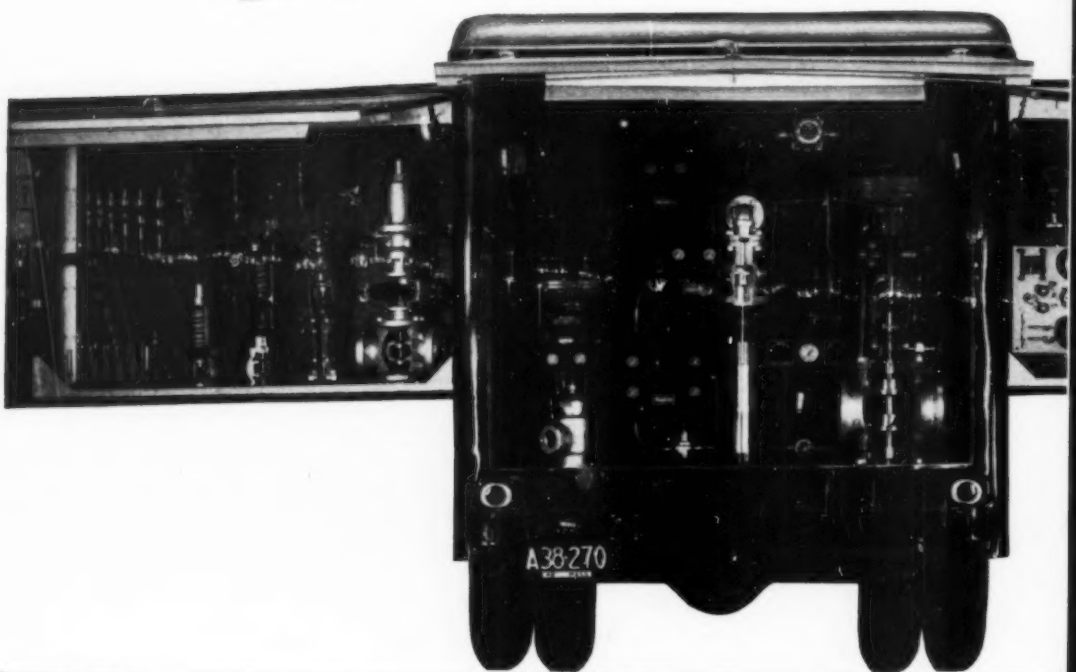

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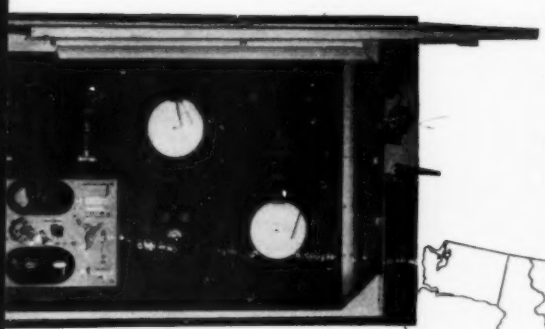

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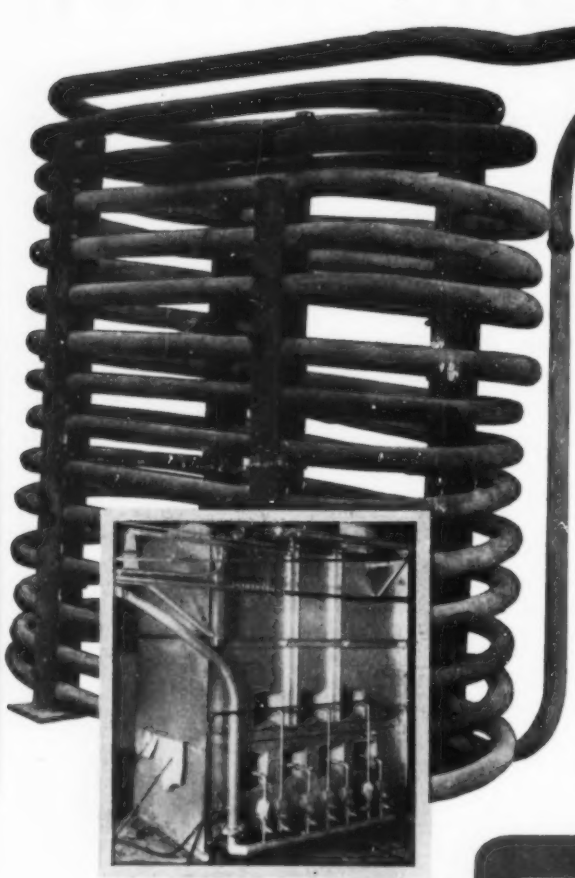

CONTINUOUS operation at 1200° F. was raising hob with the superheater coil at W. C. Hardesty Company, Dover, Ohio. The red hot temperatures were weakening the steel. Too frequent replacements were necessary and valuable hours of production time were being lost.

Learning of the problem, metallurgists of The Timken Roller Bearing Company suggested that the coil be made out of Sicromo No. 5—a special analysis Timken high temperature steel. So while the manufacturer was having a new furnace installed he decided to put in a new Sicromo coil, too. The results were amazing.

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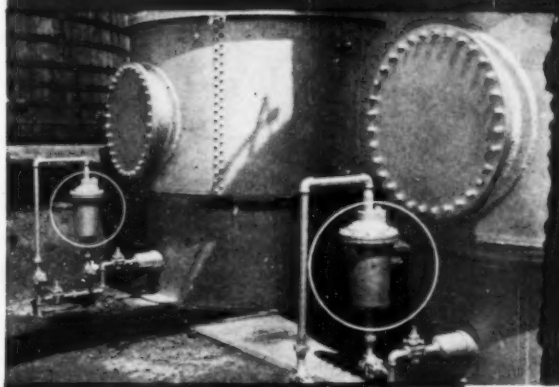

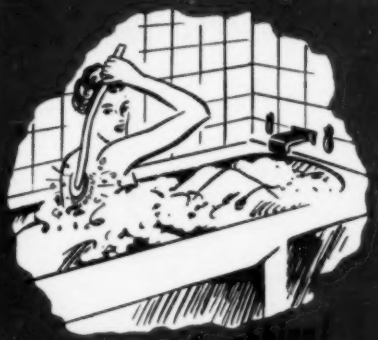

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- Greater Dependability
- Less Steam Loss

because...

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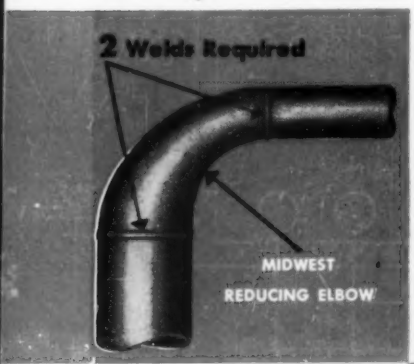

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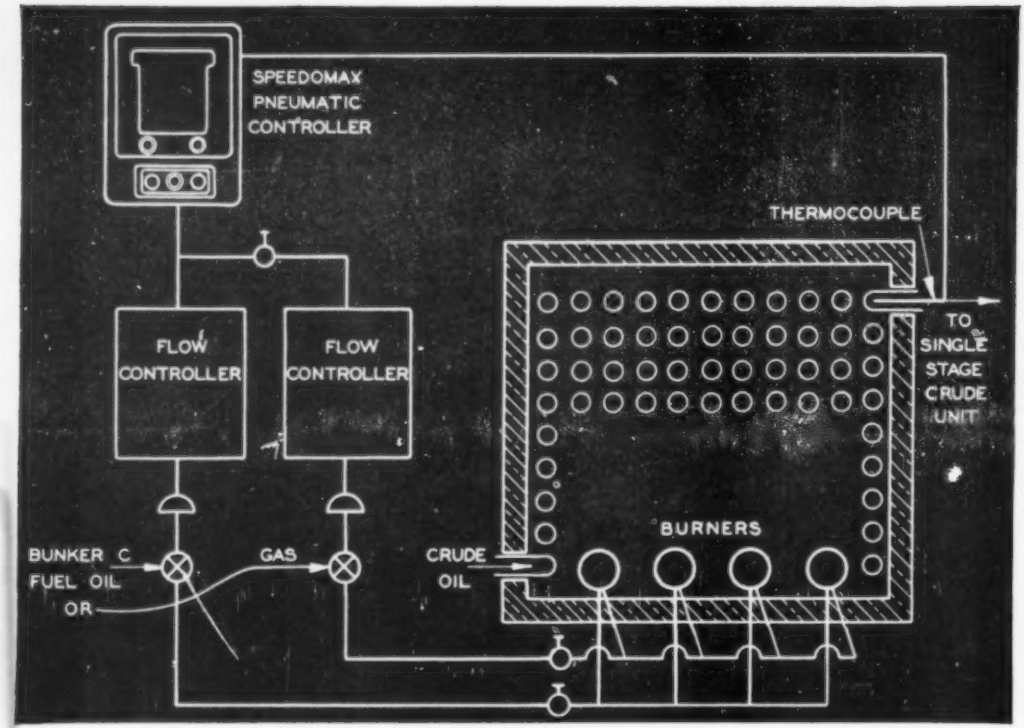

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"Well, there's a bad time lag. The stock takes several minutes to go through the furnace, from the fuel valve at the inlet to the outlet, where the thermocouple is located. Also, we burn either gas or oil—whatever fuel we have the most of, so that the fuel quality varies all over the lot."

"Another headache," he continued, "is charging stock. From day to day we charge whatever the tankers bring us. And each stock has its own characteristics, so that we must have different charging pressures and changes in furnace temperature. The whole ball of wax adds up to a real test for any temperature control."

The L&N man nodded. "Fair enough," he said. "Speedomax Pneumatic Control takes the tough jobs right in its stride. The same features of complete control that make it your best buy for your every-day control jobs will handle the toughest ones. That's the beauty of Speedomax Pneumatic—you can move it from any job to any other. You can standardize on it. Try it here and see!"

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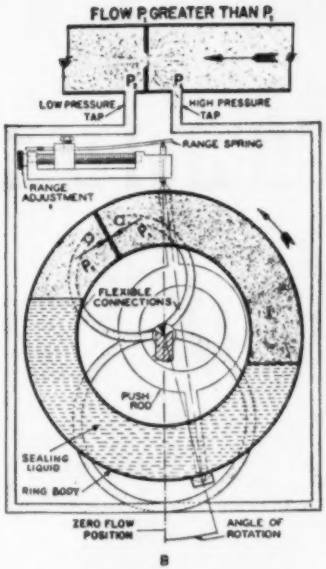
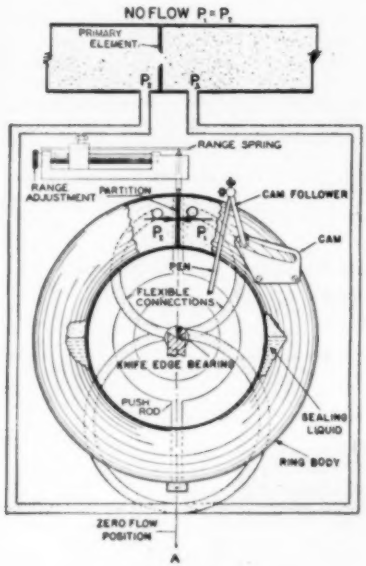
Ring Balance

principle



The Hagan Ring Balance Flow Meter is a radial torque meter which uses a hollow ring body to convert differential pressure into a rotation which is transmitted to the recorder or indicator.

The ring is divided into two pressure compartments by a baffle at the top and a sealing liquid which fills the lower part of the ring. These compartments are connected by a flexible tubing to the differential pressure pipes.



Differential pressure acting on the baffle causes the ring body to rotate about the axis of the ring. This torque is resisted by a leaf spring system located above the ring.

In Hagan Ring Balance Flow Meters, the advantages inherent in the Ring Balance principle are developed to the fullest extent. Foremost among these advantages are:

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4. Elimination of stuffing boxes.

The Ring Balance principle, plus Hagan engineering and construction, makes the Hagan Ring Balance Flow Meter a simple, rugged and accurate device, especially suitable for large scale installations because of its easy adaptability to a wide variety of applications.

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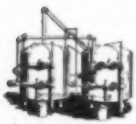

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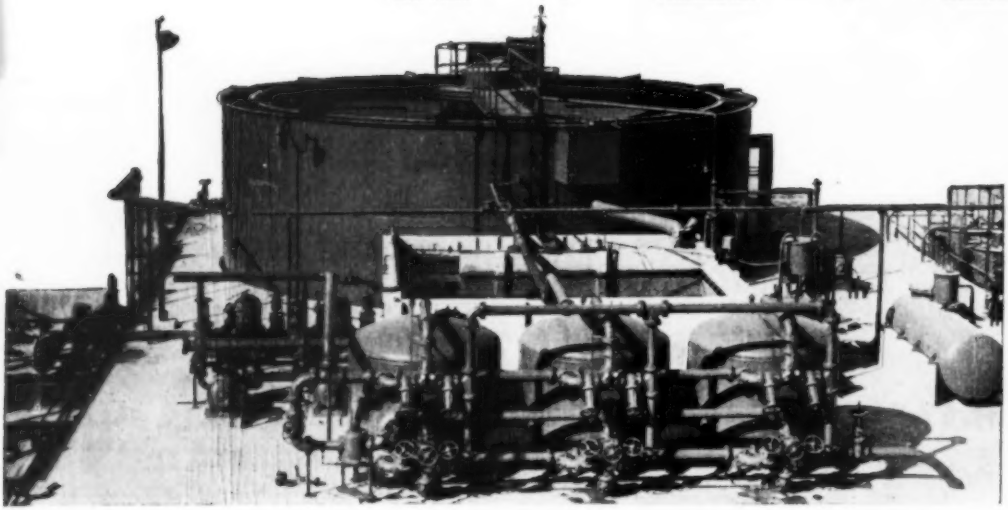

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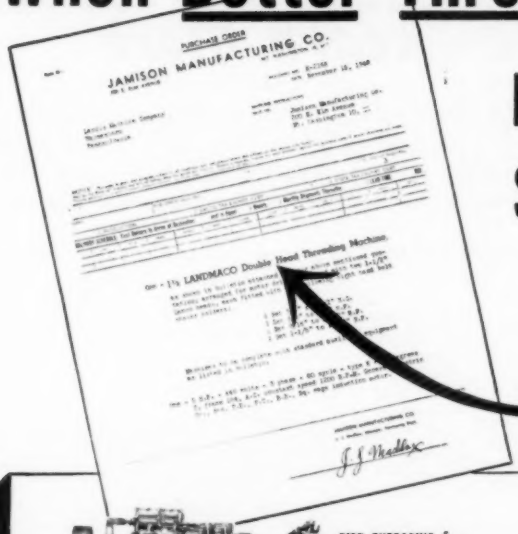

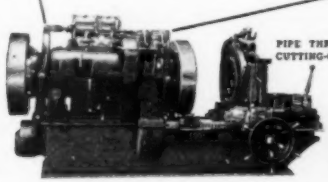

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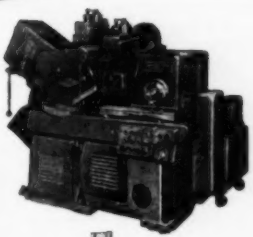

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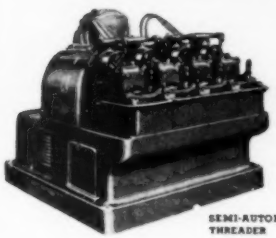
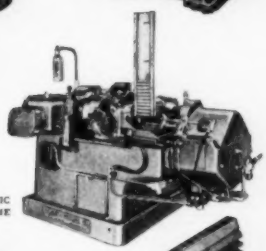
LANDMACO THREADING MACHINES



SEMI-AUTOMATIC THREADER



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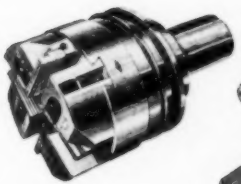

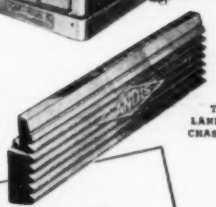

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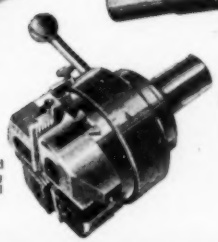

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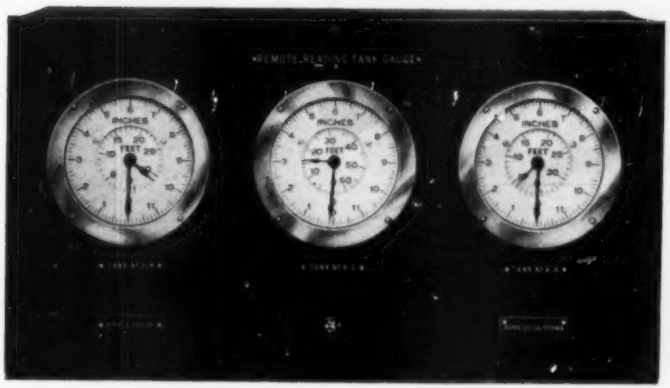

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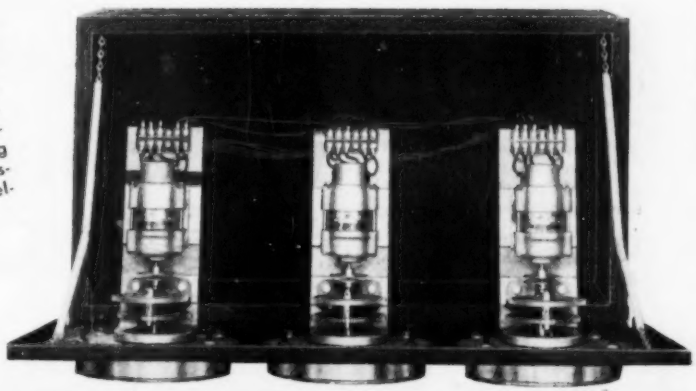

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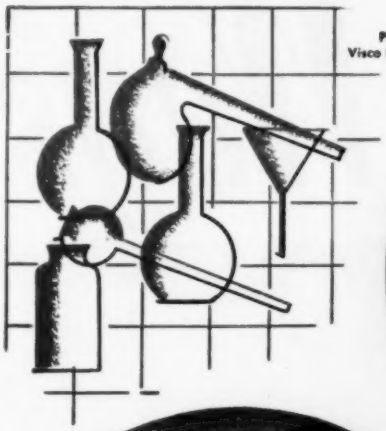

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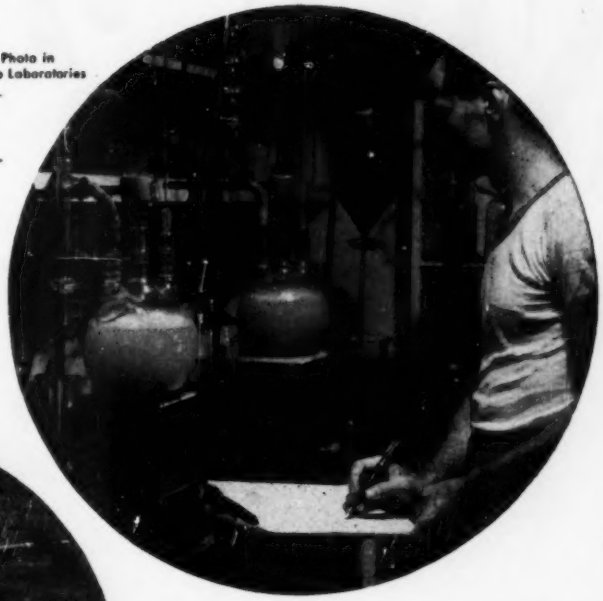

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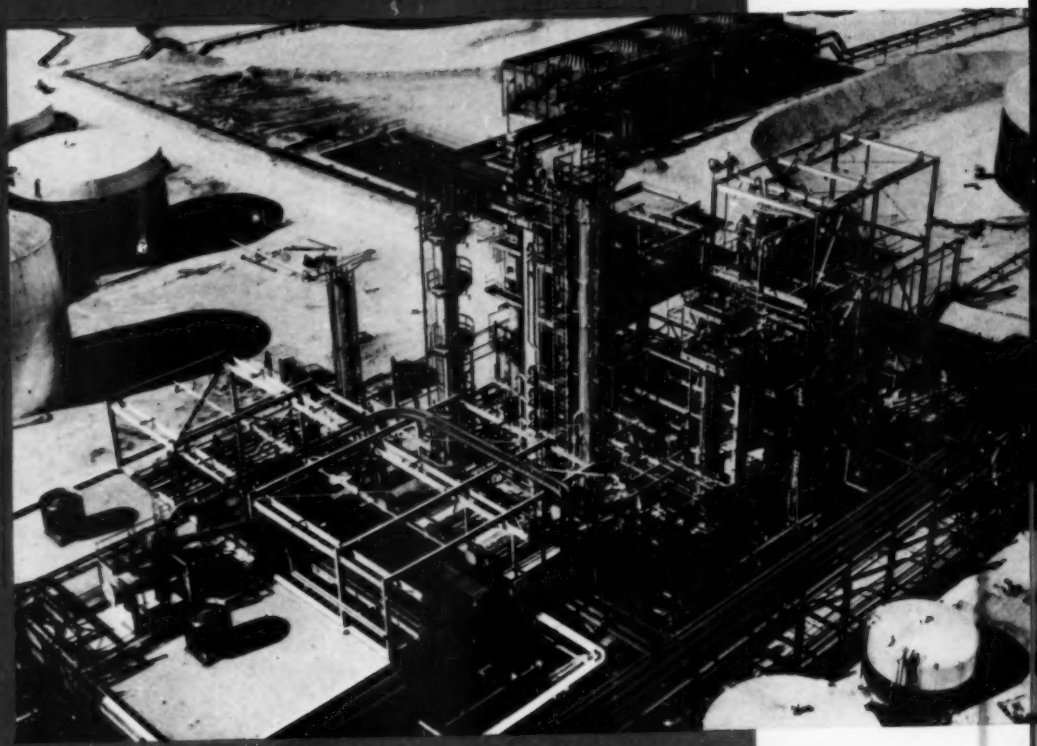

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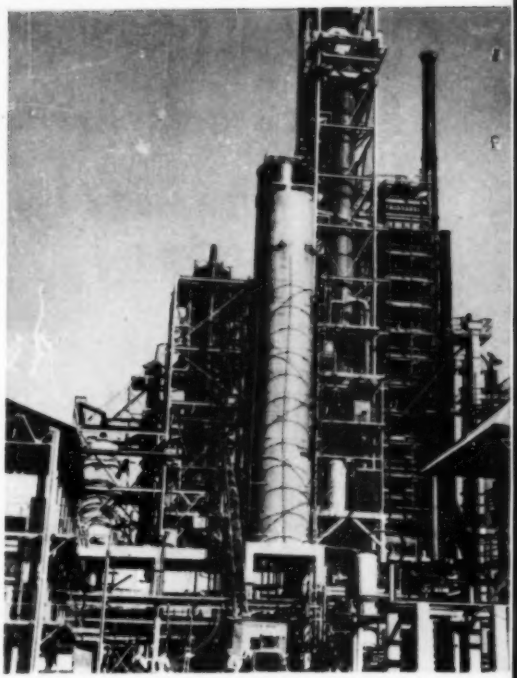

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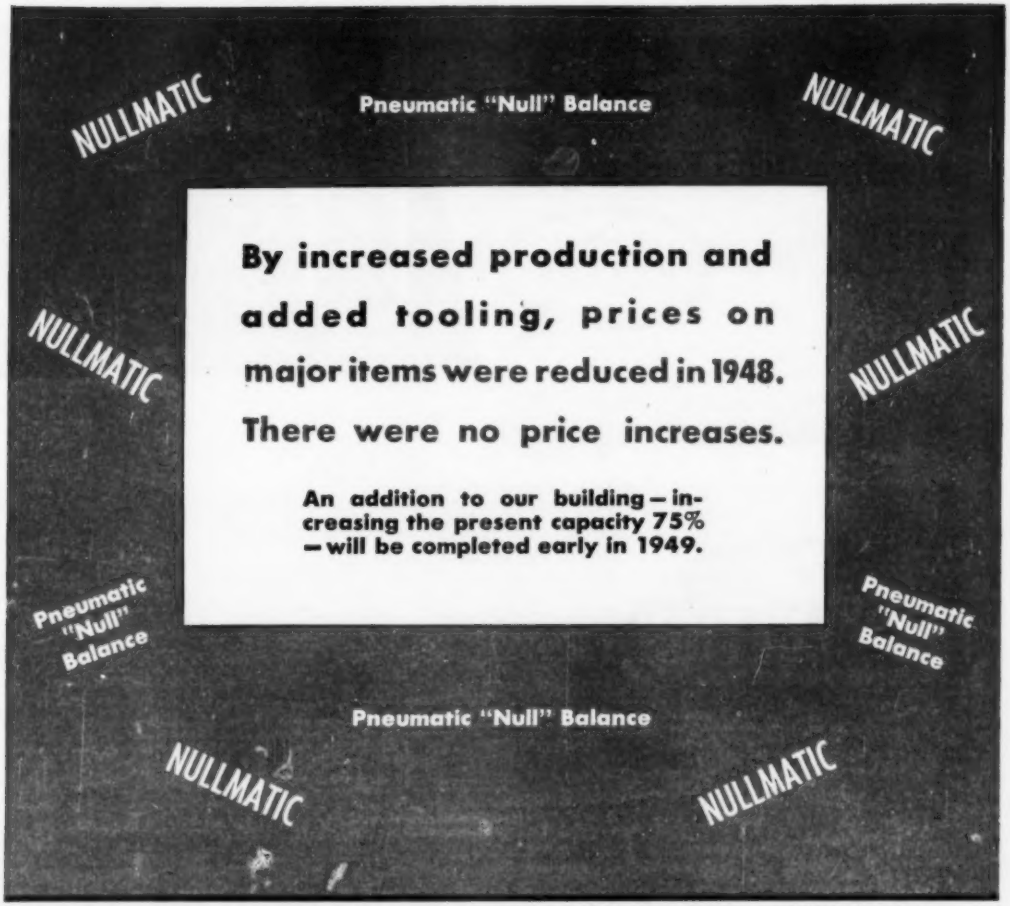
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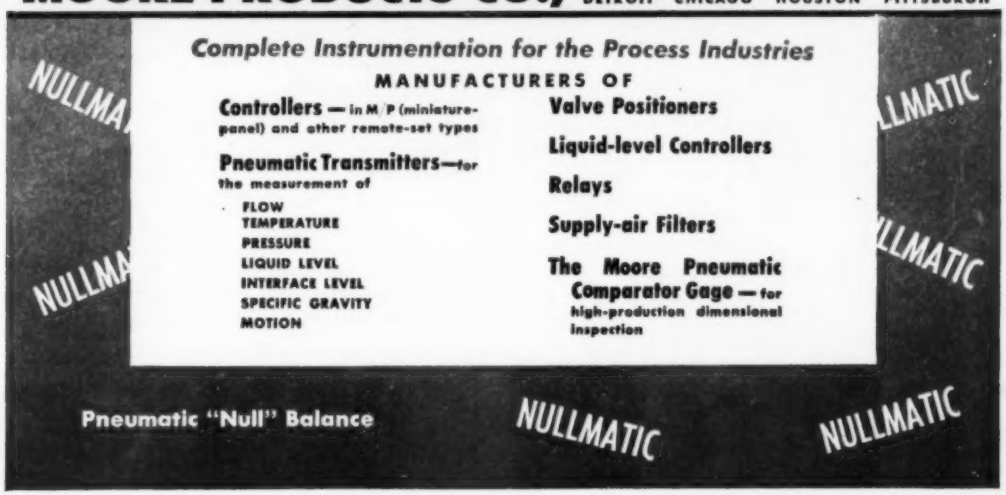

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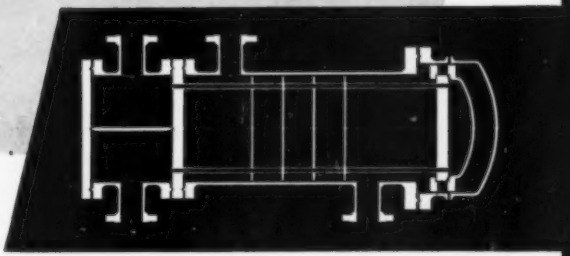

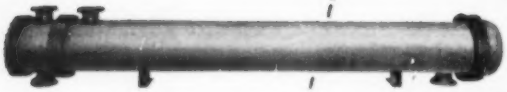

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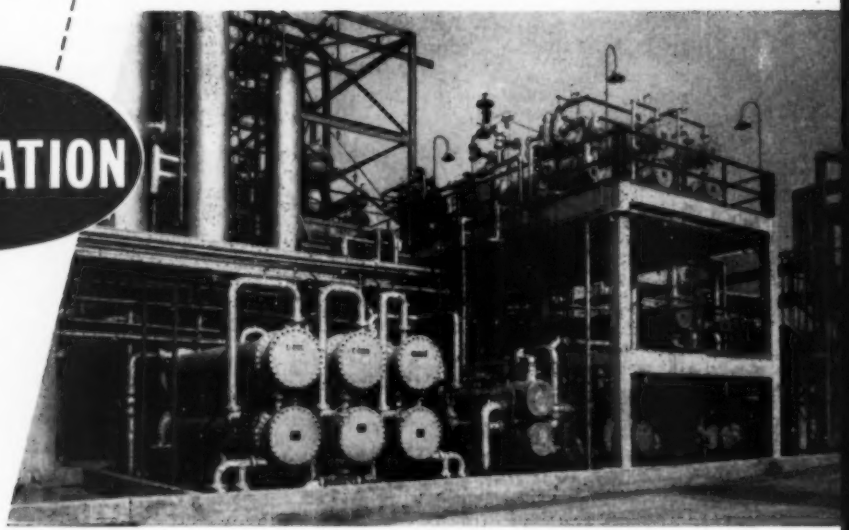

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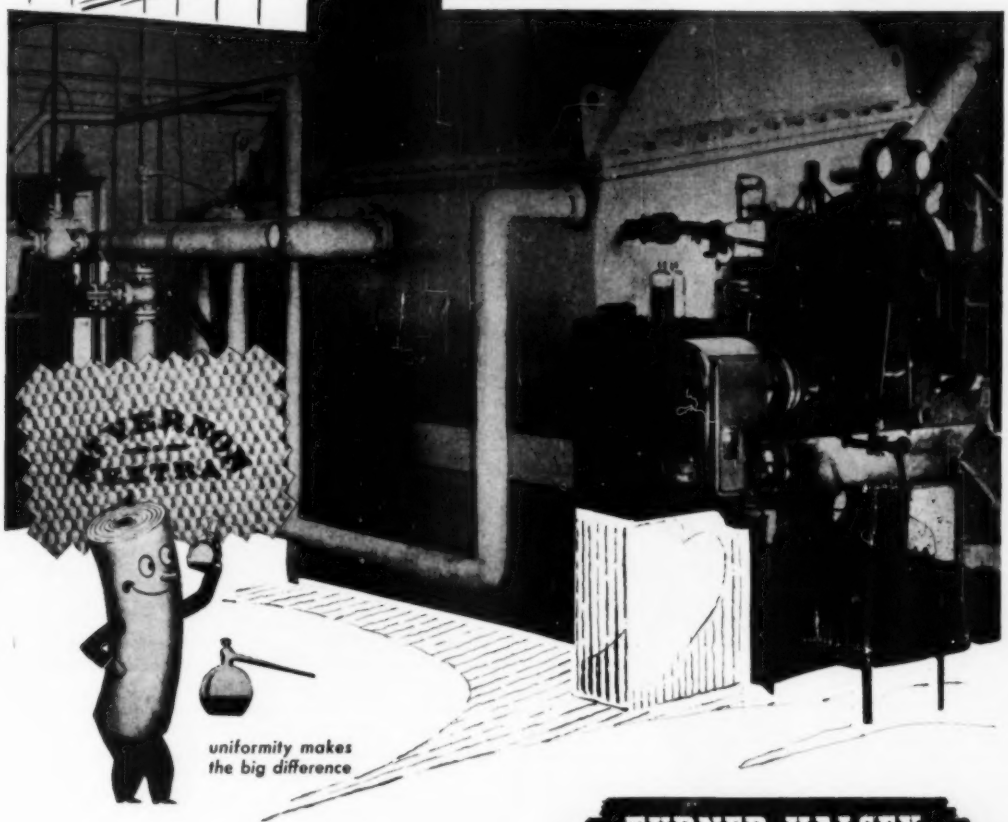

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Explosion-proof Tri-Clad motors with the new Textolite cooling fan are listed and labeled by Underwriters' Laboratories, Inc. for use in hazardous areas listed as Class I Group D (atmospheres containing petroleum, naphtha, butane, propane, alcohols, acetone, lacquer solvent vapor, and natural gas), and Class II Groups E, F, and G (metal dust, coal or coke dust, and grain dust).

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NEW G-E TEXTOLITE COOLING FAN

—plus famous Tri-Clad cast-iron construction—makes available a standard totally enclosed fan-cooled motor for corrosive refinery service

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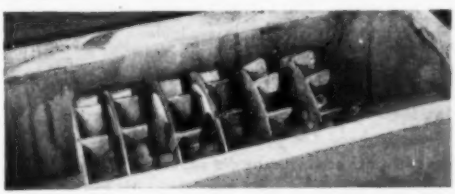
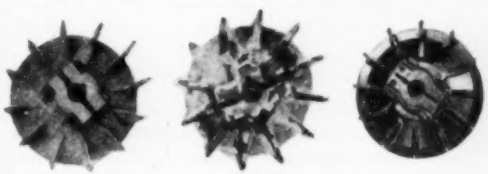


TESTED BY TORTURE! Tests that proved the resistance of Textolite to chemicals and corrosive atmospheres included the torture chamber above. Pairs of Textolite, coated metal, and uncoated metal fans were revolved on a shaft at a high ambient temperature, with acid or caustic spray directed continuously at the blades for 500 hours. This test is far more severe than any to be met in actual service.



WITHSTANDS 500 HOURS' ORDEAL! Unretouched photo shows a typical group of fans after having been subjected to a 500-hour test under hydrochloric acid spray. Note that the metal sample on the left is nearly destroyed. The coated fan in the center is partly eaten away, particularly at the outer edges of the blades. The Textolite fan, right, almost entirely unaffected by the highly corrosive acid, is good for many years of service on a motor.

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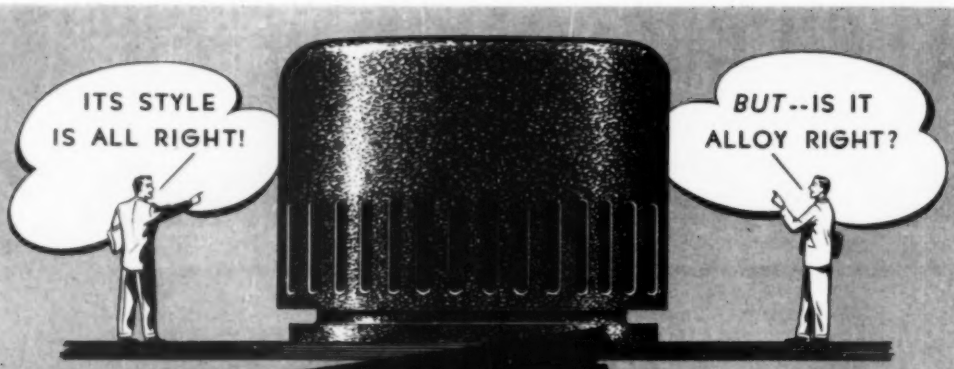

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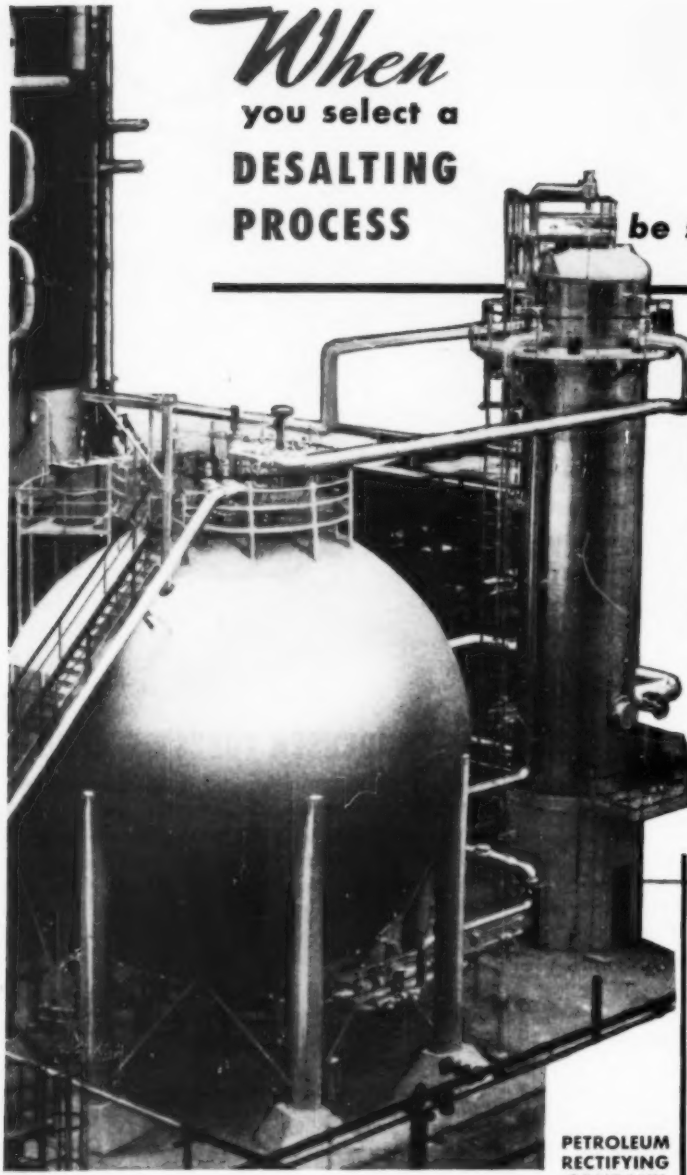

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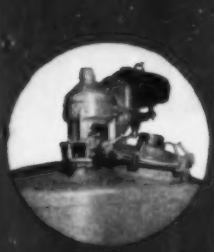
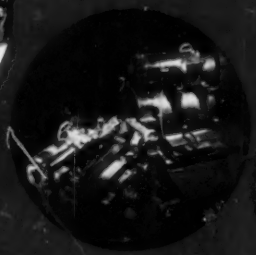
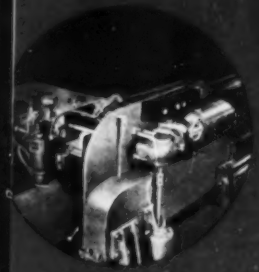






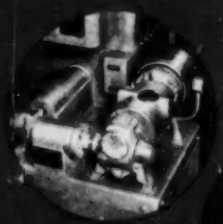
On thousands of applications, stepless variable speed operation assures exactly the right speed for every operation . . . for each operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation pays off in higher rates of production, a better quality product and more efficient performance of your equipment and your operators.

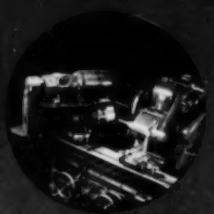
variable speed operation doesn't cost . . . IT PAYS

Master Speedrangers provide this infinitely variable speed in compact, all-metal, mechanical variable speed units in a wide range of types and sizes up to 5 horsepower.

See how the Speedrangers on the applications shown incorporate an electric motor, a variable speed unit, a gear reduction, and an electric brake . . . all standard Master units that easily combine into a compact, integral power drive. This provides exactly the right speed, the right features, in a unit that you can use right where you want it.

Write for Data 7525, a new 24-page book on Speedrangers, and see what a real job they can do for you.





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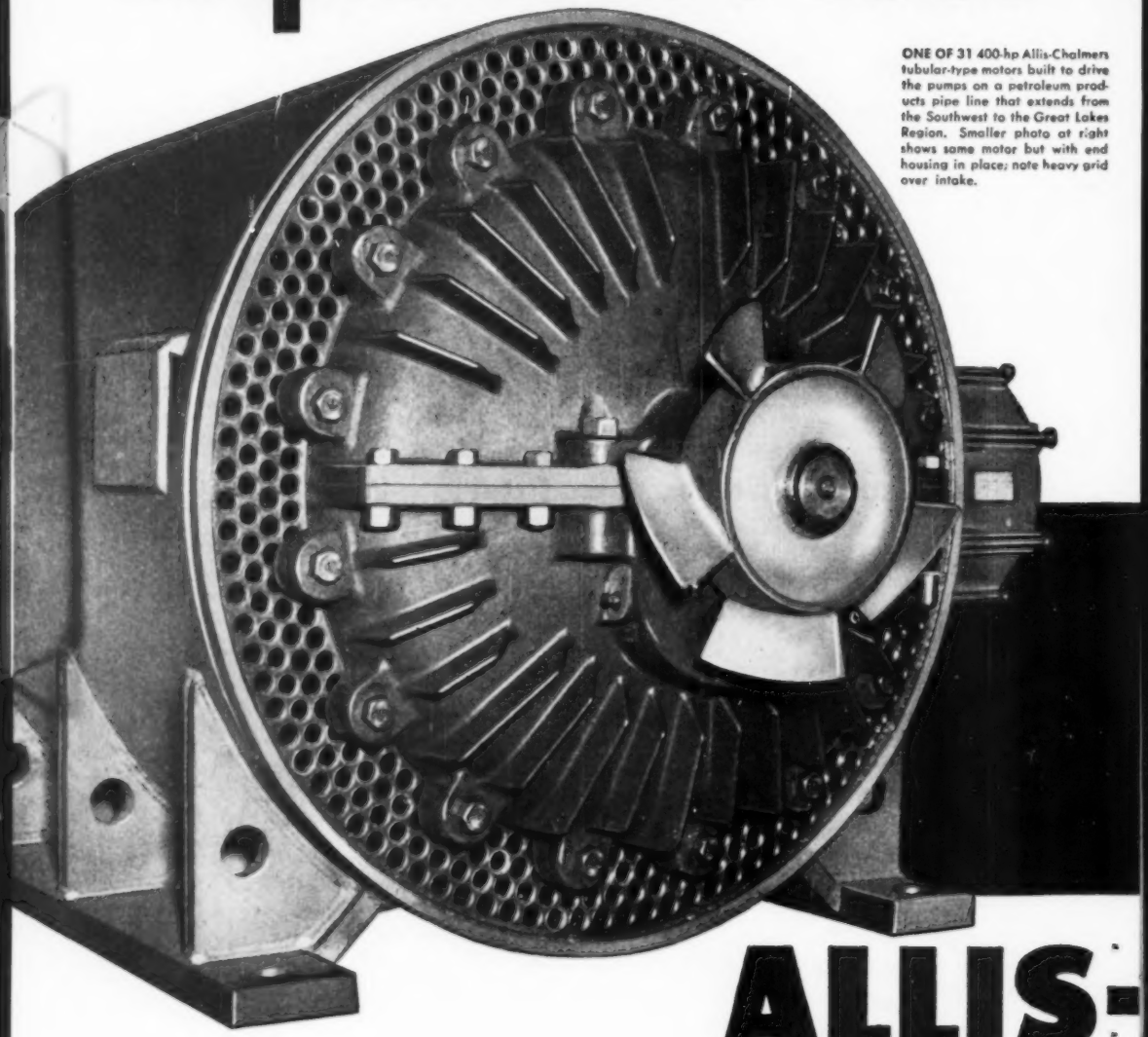
ANNOUNCE Explosion-Proof



ONE OF 31 400-hp Allis-Chalmers tubular-type motors built to drive the pumps on a petroleum products pipe line that extends from the Southwest to the Great Lakes Region. Smaller photo at right shows same motor but with end housing in place; note heavy grid over intake.

ALLIS-

Power, Electrical, Processing,

New Tube-Cooled Motors!

IN RATINGS 150 TO 600 HP . . . FOR CLASS I, GROUP D AND CLASS II, GROUP G LOCATIONS

ALLIS-CHALMERS totally-enclosed, fan-cooled squirrel cage motors with Underwriters' *Explosion-Proof* labels for 1-D and 2-G locations are built in ratings of 250 to 400 hp at 3600 rpm . . . 200 to 300 hp at 1800 rpm . . . and 150 to 200 hp at 1200 rpm. Motors above and below these sizes are available in a similar design.

COOLING SYSTEM PROVED BY PERFORMANCE IN THE PAST

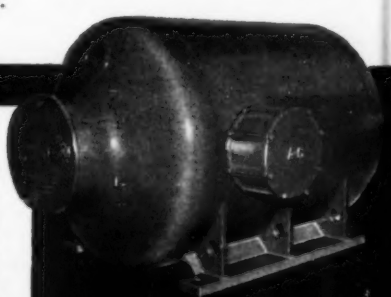
The system of cooling has been used for about three years by Allis-Chalmers on much larger totally-enclosed, fan-cooled motors. These larger ratings have been successfully used for many types of applications in power plants, chemical plants, pipe lines, and refineries . . . indoors and outdoors.

A nest of straight tubes in the circumference of the stator frame forms an air-to-air heat exchanger of high efficiency. The tube ends are tightly fitted into drilled steel plates at each end of the motor. The electrically active parts are fully protected from contact with outside air.

Internal fans continuously circulate the clean inside air around the nest of tubes, while a fan between the intake end cover and the end plate forces external air through the tubes and back into the atmosphere. Heat is transferred from the internal air to the atmospheric air by conduction through the tube walls.

For other features of this Allis-Chalmers tubular-type *Explosion-Proof* motor, see the outline below. For more information on the motor and its applications, call your nearby A-C office, or write direct for bulletins 05B7150 and 51R7149. A 2581

ALLIS-CHALMERS, 1062A SO. 70 ST.
MILWAUKEE, WIS.



These Features Mean Long, Dependable Drive Performance

1. **COOLING SYSTEM** is virtually self-cleaning. Forced air flow and straight tubes extending from front to rear prevent clogging — keeps system operating with high efficiency and reduces maintenance.

2. **STURDY CONSTRUCTION** assures long service and minimum maintenance. Special metals may be used where needed to meet corrosive atmospheric conditions.

3. **RINGS WELDED** into yoke are drilled to receive cooling tubes. Chamfering of holes in two end plates, expanding of tubes in holes, and flaring of tube ends produce joints which have met Underwriters' explosion tests. This construction keeps explosive mixtures out of motor and keeps the internal parts clean.

4. **EXTERNAL FAN HOUSING** is specially designed to assure proper flow of air to the tubes. Where sleeve bearings are used, a lucite cover permits inspection of the oil ring through the oil ring inspection plug with motor operating or idle. A strong grid covers the intake preventing accidental contact with the fan.

CHALMERS

and General Machinery for the Petroleum Industry

American engineering practice

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HEAD WRIGHTSON PROCESSES LIMITED are Accredited Engineers for Leading American Refinery Processes including Thermal and Catalytic Cracking and Reforming, Solvent Extraction and Dewaxing, Desulphurisation, Chemical Treating, Continuous Charcoal Adsorption, etc. . . . All Plants engineered in strict accordance with American practice, and to American Codes. . . . Ten plants, including some of the largest Solvent Extraction Plants in the World, engineered by Head Wrightson Processes Ltd., are now in course of construction. Our services comprise engineering, purchasing, progressing, inspection, shipping, and supervision of erection.

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Take a Catalyst Storage Hopper, for example. Crane supplies all valves, fittings, accessories, fabricated piping or pipe, for this as well as for any other refinery installation. One catalog gives you the world's most complete selection of brass, iron, steel and alloy piping materials... all designed to meet rigid refinery specifications.

Making Crane your **Single Source of Supply** simplifies all piping procedures, from design to erection to maintenance work. One order to nearby Crane Branches or Wholesalers covers everything for the job. **One Responsibility** for materials helps to get better installations, avoids needless delays. And to standardize on the **High Quality** that is Crane Quality assures dependable piping performance from every item in your system.

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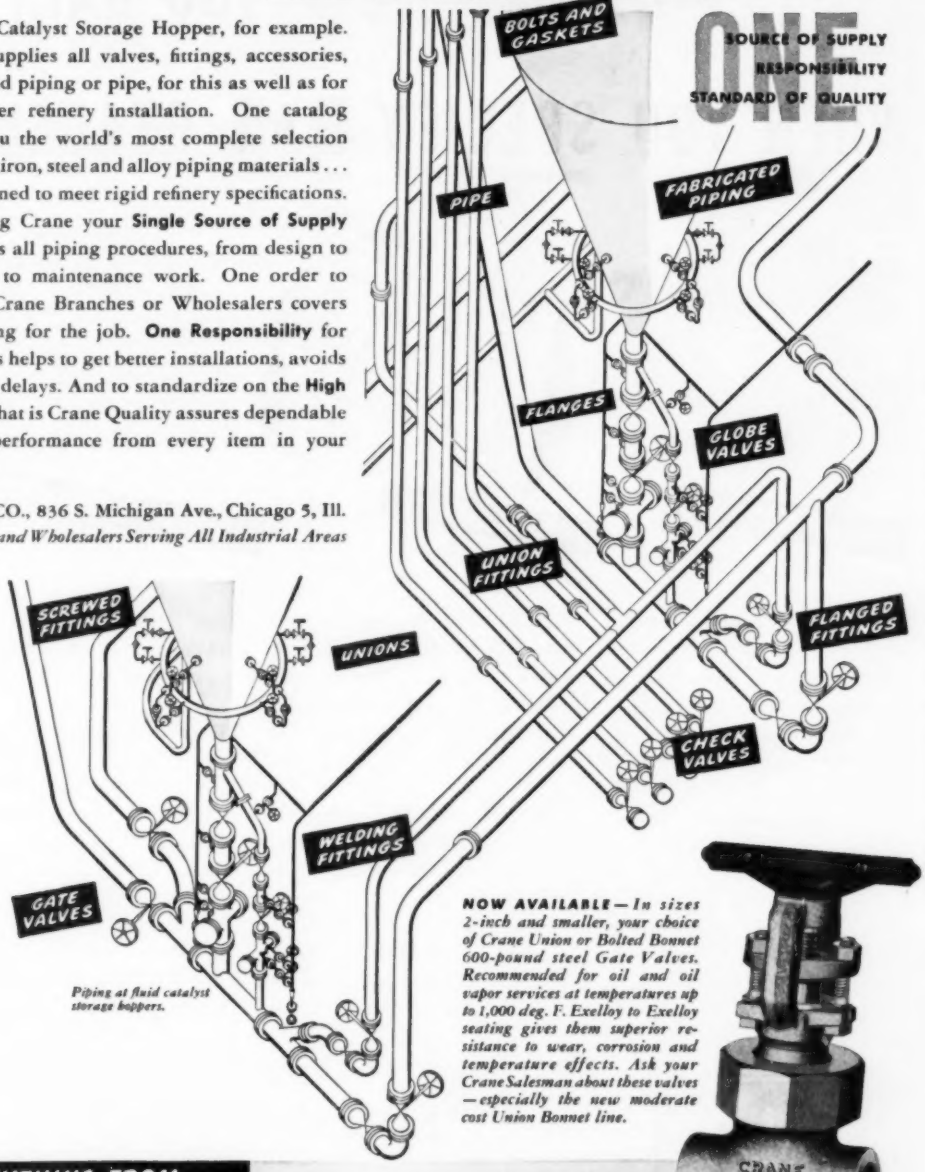

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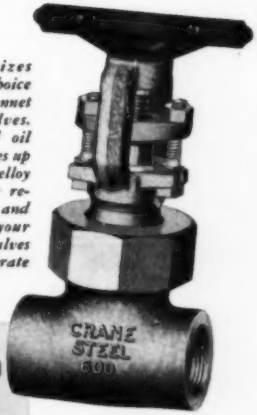

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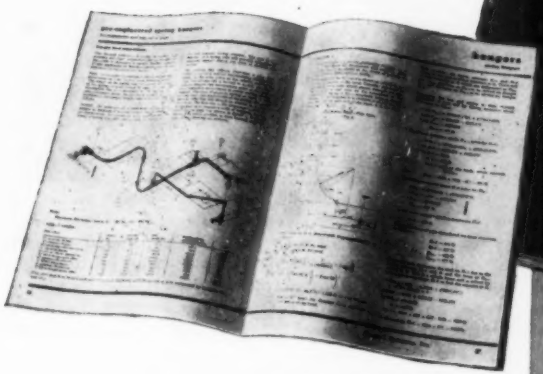

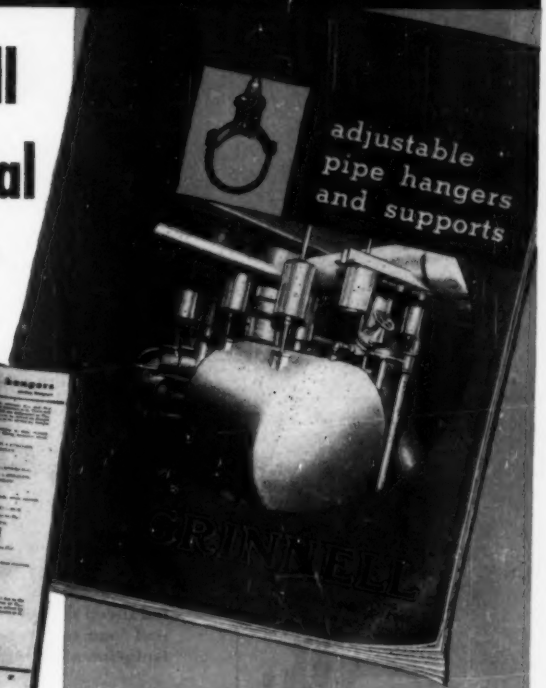

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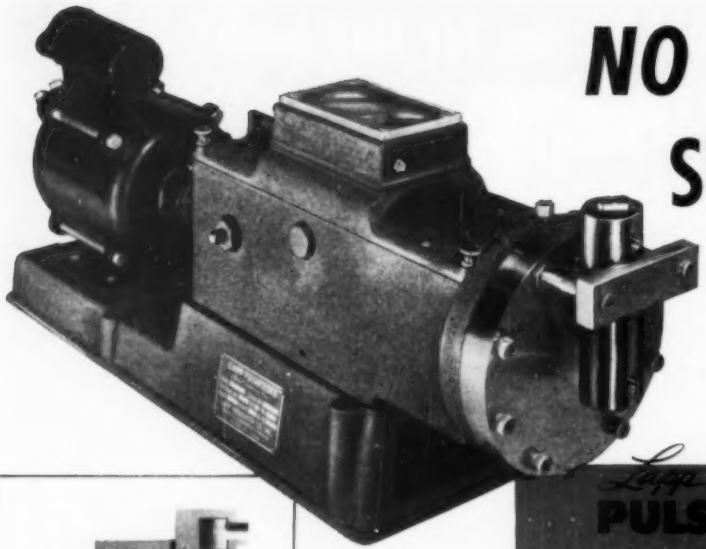
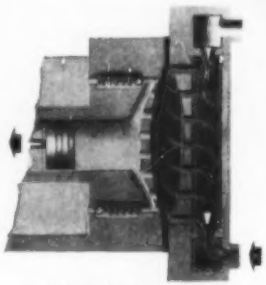
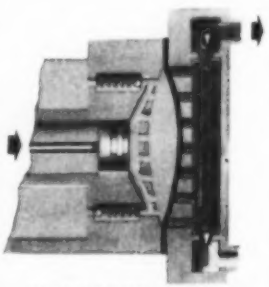


Lapp
PULSAFEEDER
PISTON-DIAPHRAGM PROPORTIONING PUMP



INTAKE STROKE



DISCHARGE STROKE

● Operation of the Lapp Pulsafeeder depends on no mechanical or liquid seal; no packing or other "leak-likely" gland can be in contact with liquid being handled. Instead, a hydraulically-balanced diaphragm acts as a floating partition, without mechanical load or pressure differential across it. This assures complete isolation of chemicals being pumped from all working pump parts.

HYDRAULICALLY-BALANCED DIAPHRAGM, made from the most suitable of several available materials, is confined by machined "dishes" within its fatigue limit, secure against failure.

CHEMICAL ISOLATED by diaphragm from working parts of pump.

MICRO-ADJUSTABLE to any rate of flow by calibrated handwheel, *while pump is in operation.*

PERFECT LUBRICATION — all moving parts submerged in oil bath.

CAPACITY ranges from less than 100 ml. per hour to 660 gallons per hour; pressures up to 2250 psig. Single head and duplex models are available in a range of four sizes.

SEND FOR BULLETIN No. 262 which carries complete description and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 163 Maple St., Le Roy, N. Y.

Lapp *Process Equipment*

CHEMICAL PORCELAIN VALVES
PIPE • RASCHIG RINGS
PULSAFEEDER PROPORTIONING PUMPS

AN "EYE-OPENER" IN

Accessibility

NO GROPING for concealed adjustments! No "sweating out" of awkward alignments! No haphazard arrangement of parts to cause confusion! Everything about the Foxboro Model 40 Controller is designed for orderly accessibility as well as precision.

With the door opened, operating controls are all conveniently grouped in the upper right corner. *Instantly accessible!* Pressure reducing valve and transfer switch are equally handy. Simple removal of chart plate (no tools, no pen-removal) makes all working parts easy to reach . . . with unit construction throughout to insure automatic re-alignment, even after disassembly and reassembly.

This outstanding accessibility is only one of many advantages that result from top-to-bottom new design that makes M-40 the finest modern controller!

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M-40

"THE FINEST MODERN CONTROLLER"

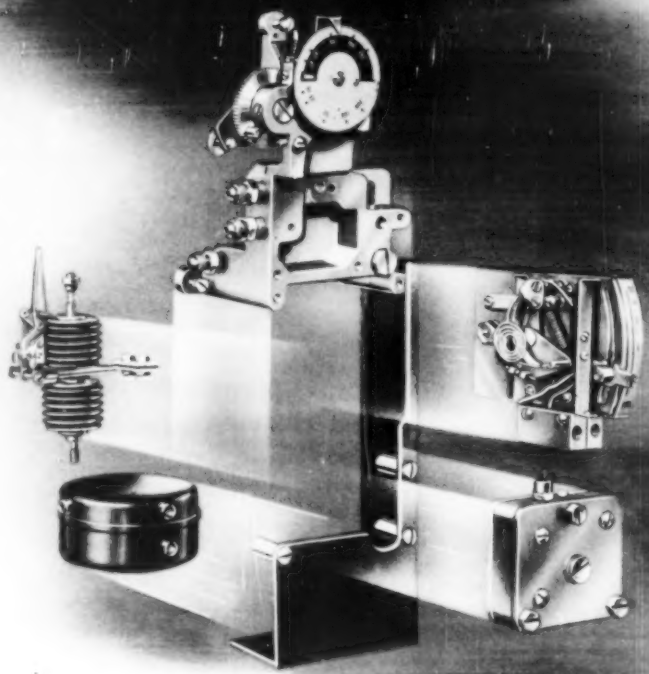
The Model 40 Pneumatic Controller is available for temperature, pressure, flow, liquid level, humidity, density, etc., in a full range of control actions and combinations. Write for Bulletin 381.
The Foxboro Company, 262 Neponset Avenue, Foxboro, Mass., U. S. A.

The only control unit with

PERMALIGNED CONSTRUCTION

The complete Model 40 control unit incorporating flapper and nozzle, control relay, hydron system and resistances is actually a series of sub-assemblies mounted on a single, solid base casting. Because of its overall unit construction, sub-assemblies as well as the entire unit may be removed or replaced easily and quickly without destroying original alignments.

Here's a typical example of the *permaligned* construction throughout the M-40 Controller . . . another important reason why instrument men recognize the M-40 as the finest modern controller.



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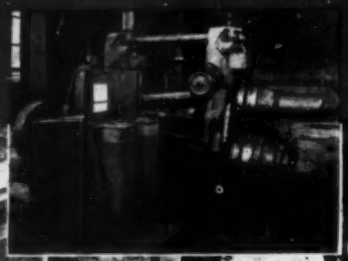
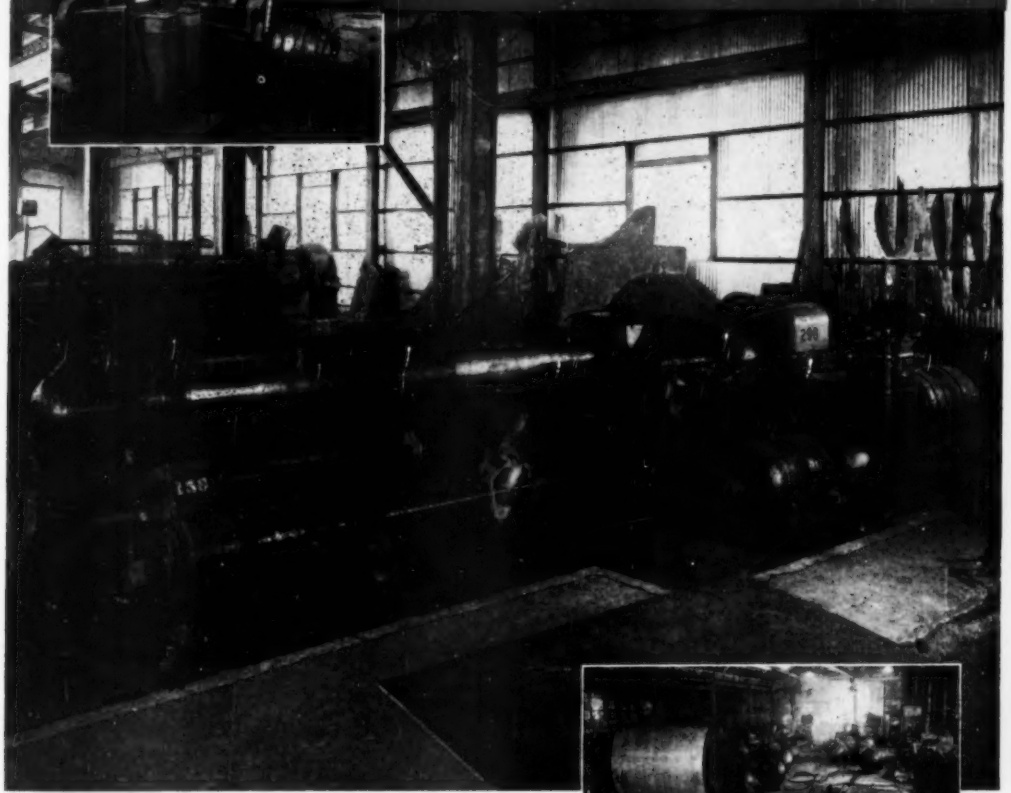
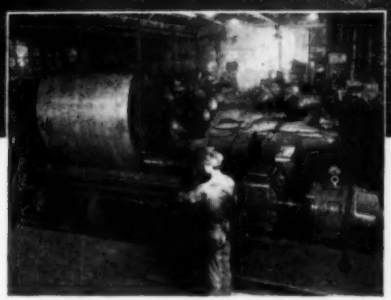
"THE FINEST MODERN CONTROLLER"

FABRICATION FACILITIES







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ENGINEERING . . .

Continued efficiency of refining facilities depends largely upon engineering knowledge available, not only during the periods of design and construction, but after these facilities have been placed in operation. That is why Universal places so much importance on basic engineering "know-how" . . . why this same "know-how" and long-time experience is made easily available to all refiners regardless of size or extent of operations.

UOP

Aurora Reports on Second Turnaround of Fluid Unit

By Max M. Fisher
Vice-President, Aurora Gasoline Company

FOLLOWING the second shutdown of our 4,000 bbl./day fluid catalytic cracking unit at Detroit, we began the third run at 11 PM, Nov. 3, 1948. This second shutdown required only 79 hours after a total of 324 days on stream. Efficiency of our second run has been calculated at 98.5 percent, and combined with the results of our first run of 176 days, shows an overall efficiency for the unit of 96.1 percent. Tables below give this information in detail.

Max M. Fisher

The fluid unit, designed and engineered by Universal Oil Products Company, was placed on stream for the first time in June of 1947. It combines reactor and regenerator in a single column, a factor that resulted in materially reduced construction costs when compared with those required by the fluid cat cracker of earlier design. We consider this a real saving as the unit has afforded excellent flexibility with improved product return. We are now equipped to handle a wide range of charging stocks without difficulty and are able to keep pace with market demands as they change.

The design of the cat cracker itself, together with the engineering and field service offered by its designers, has proved in a large measure responsible for the efficient operating schedules shown in these tables.

Report of Second Run

Date & Time of Actual Startup	6 PM, Dec. 12, 1947
Date & Time on Stream	4:30 PM, Dec. 13, 1947
Date & Time of Shutdown	12:30 AM, Nov. 1, 1948
Days on Stream	324
Total Hours of Run	7,761
Total Hours on Stream	7,711
Total Hours off Stream	50
Total Hours Shutdown	79
Efficiency	98.5%

The 50 hours off stream as noted in this report of the second run were required for the repacking of valves and couplings, the correction of minor electrical difficulties, the connecting in of a new cooling tower and the cleaning of the water side of flue gas steam generator.

Overall Efficiency

The combined results of both the first and second runs have been tabu-

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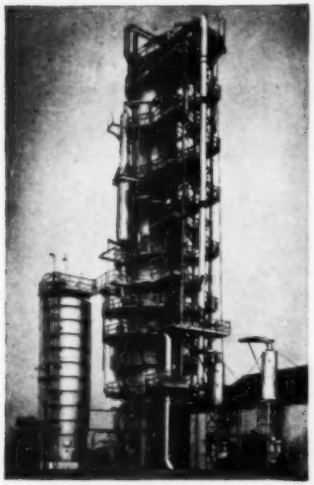

Fluid catalytic cracking unit at Detroit refinery of Aurora Gasoline Company.

lated as follows:

Total Hours, Runs 1 and 2	12,315
Total Hours on Stream	11,858
Total Hours off Stream	126
Total Hours of Shutdown	331
Efficiency	96.1%

Normal operating and maintenance personnel accomplished both turnarounds, and in both, the requirements are considered more than satisfactory. For the first, after 176 days on stream, 4,508 man hours were necessary. The second, after 324 days on stream, called for only 1,677.

Catalyst Losses Below Estimate

For a total raw oil charge of 1,405,384 barrels (average of 4,340 bbls./S.D.) during the second run, total catalyst loss has averaged .207 pounds per barrel. This figure is actually lower than the minimum estimated by the designers of the unit prior to its construction and has contributed considerably to the efficiency of our operation.

UOP Process Book

A 24 page booklet describing in detail the processes licensed by Universal Oil Products Co. is now available. Complete flow diagrams accompany the dicussion of each process.

In addition, the book deals with Universal inhibitors, downdraft equiflux and center-wall heaters, and the various services offered to the company's licensee refiners.

The processes discussed include: fluid catalytic cracking, thermal cracking, catalytic polymerization, paraffin alkylation, Unisol mercaptan extraction, thermal reforming, isomerization, catalytic dehydrogenation and catalytic desulfurization.

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FIELD SERVICE . . .
In providing adequate field service to licensee refiners, Universal contributes to the successful and economical operation of refineries in all parts of the world. It is a thorough and complete service that covers practically every phase of refinery operation and assures maximum safety, efficiency and economy. It is a service that has helped many refiners keep their operations at a profitable level.
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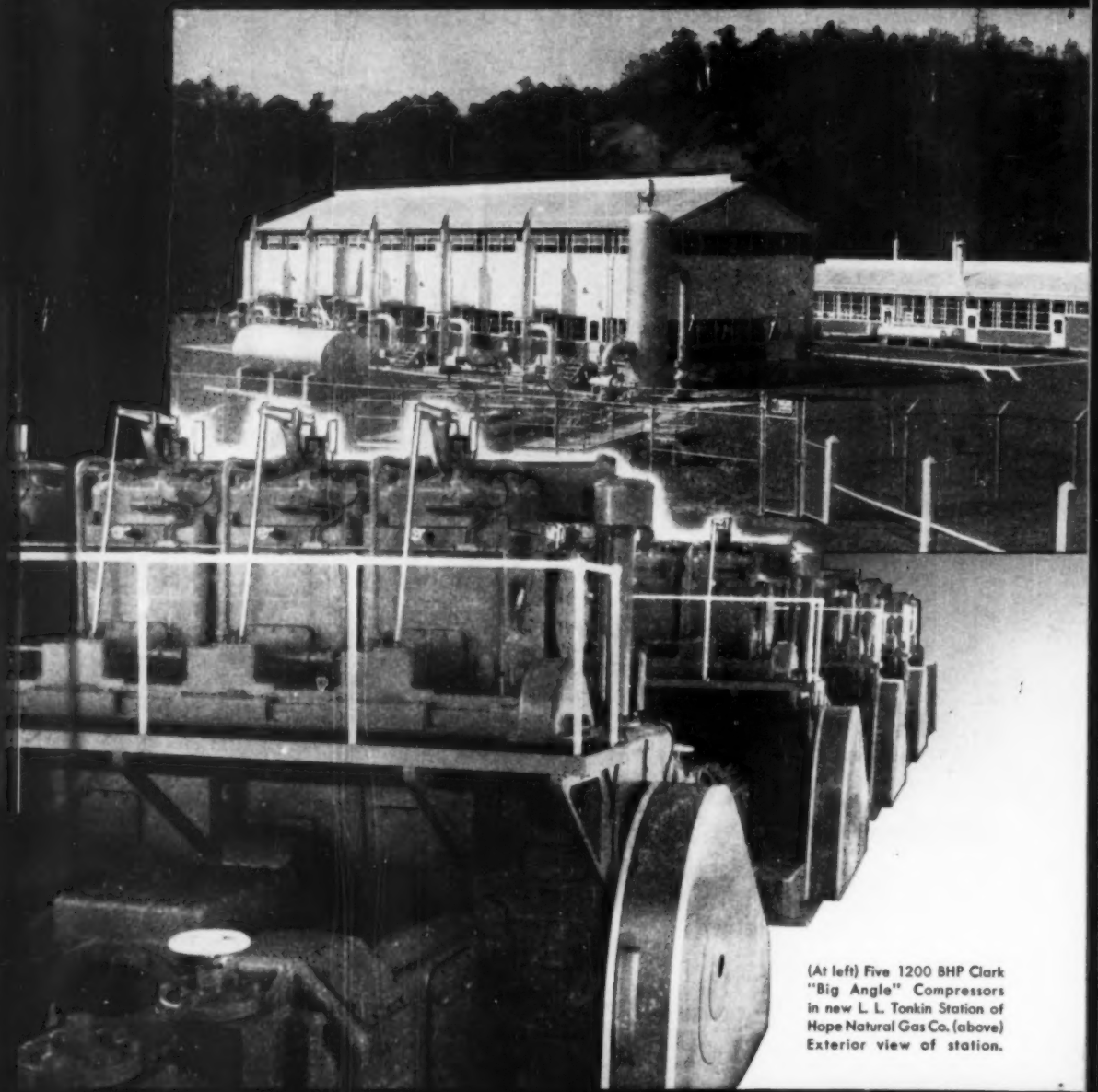
HOPE NATURAL GAS USES



(At left) Five 1200 BHP Clark "Big Angle" Compressors in new L. L. Tonkin Station of Hope Natural Gas Co. (above) Exterior view of station.

CLARK

ONE OF THE DRESSER INDUSTRIES

"BIG ANGLES"

CLARK "BIG ANGLES"

IN NEW L. L. TONKIN STATION

L. L. TONKIN. Since his graduation from Cornell University in 1912, Loring L. Tonkin has worked continuously for the Hope Natural Gas Co., as meter engineer, construction foreman, division engineer, compressor station superintendent, assistant general superintendent, chief engineer, general manager and president. He is also a director of the Consolidated Natural Gas Co. and other associated companies.

It's not surprising that the working staff at "the best looking compressor station east of the Mississippi", chose to name the new station for their chief, Loring L. Tonkin, president of the Hope Natural Gas Company.

L. L. Tonkin Compressor Station is one of the most important links in the company's transmission facilities. Through this modern station in the West Virginia Hills, gas is moved to hundreds of thousands of users in Northern Ohio and Central New York.

Five 1200 BHP Clark "Big Angle" Compressors handle the gas, which is received at a pressure of 650 psi and discharged at 1100 psi.

The Clark "Big Angle" has demonstrated its economy and superior performance on many of the most important projects constructed in recent years. It is the most compact heavy-duty gas-engine-driven compressor unit ever built. Delivering 200 horsepower per cylinder, this unit is available in 5, 6, 8 and 10 cylinder sizes.

Write for full information, or phone the nearest Clark office listed below.

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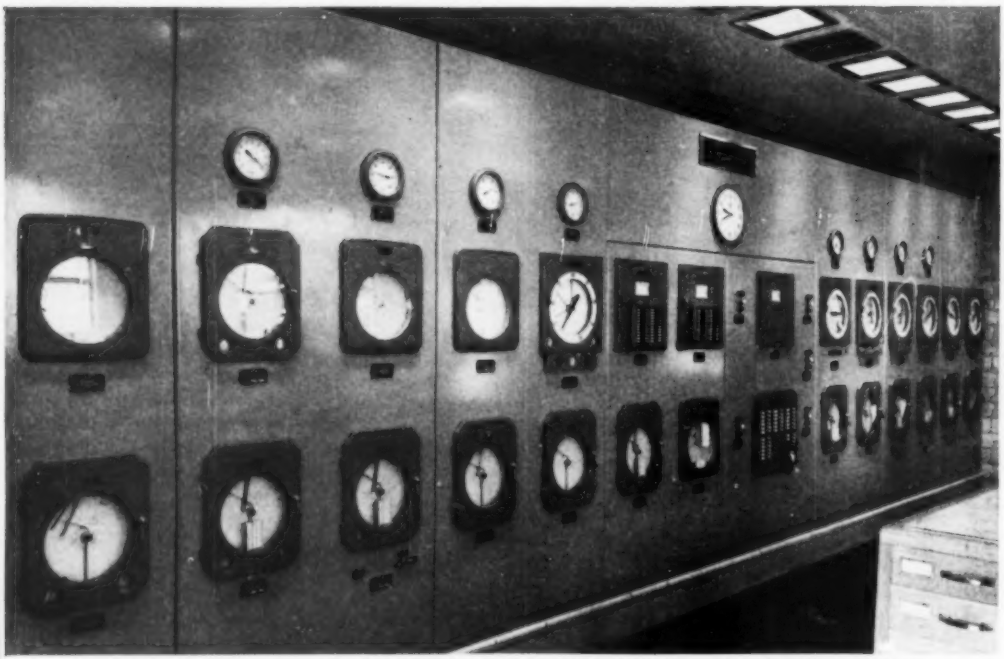
Whatever type of Compressor you need, *CLARK MAKES IT*

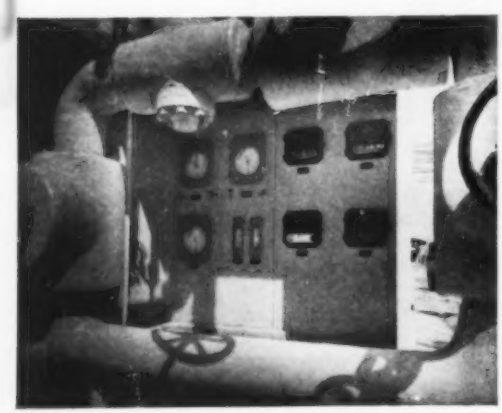
Send for new bulletin on the Clark Big Angle with complete description, dimensional drawings and other useful data.

WHERE ACCURATE

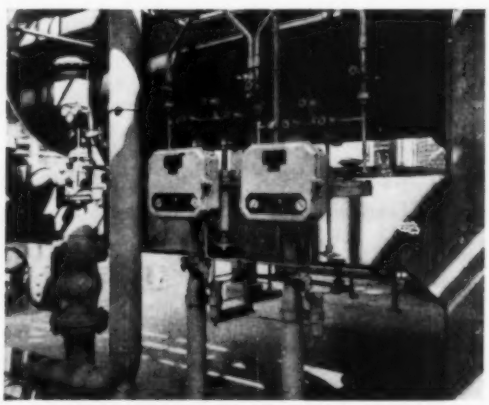
. . . Shell depends on Taylor Instruments at many



Central Control Room Instrument Panel at Shell Chemical Corporation's synthetic glycerine plant, Houston, Texas.



Taylor Fulscope Pressure, Flow, and Level Controllers at an outdoor control station.



Taylor Fulscope Indicating Flow Controllers locally mounted on plant equipment.

CONTROL IS VITAL

critical points in its new synthetic glycerine plant

TAYLOR INSTRUMENTS are helping make the industrial dream of a century come true at the Shell Chemical Corporation's huge new synthetic glycerine plant at Deer Park, Texas. In a multitude of essential operations at this plant, the world's first commercial synthetic glycerine plant, Taylor indicating, recording and controlling instruments are contributing to successful operation.

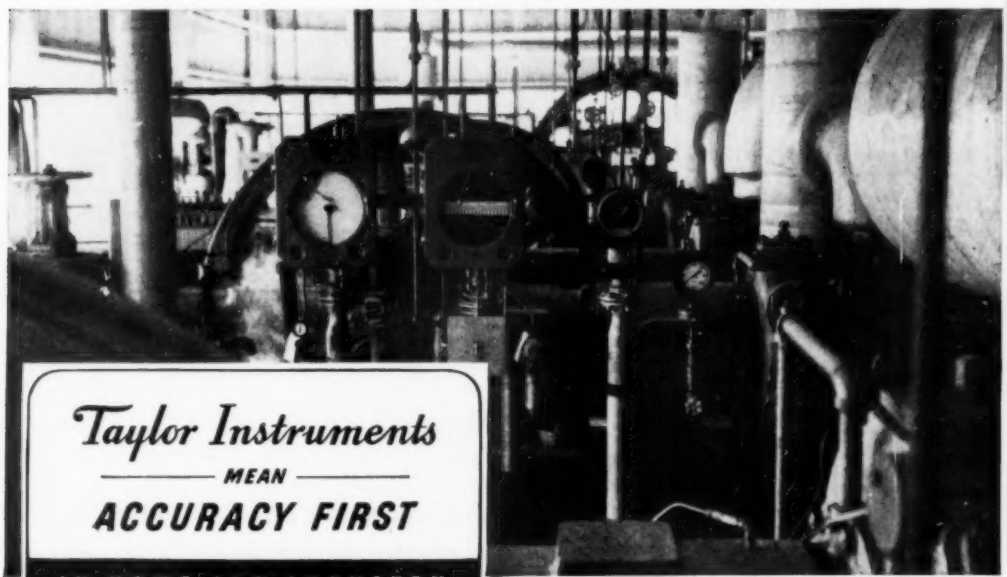
The $8,000,000 project began with a table-size laboratory model. For more than a decade, Shell scientists experimented with glycerine produced on this scale model until both product and process were perfected. Then blueprints of the process were turned over to C F Braun & Co, who built the new commercial plant.

Shell Chemical Corporation and C F Braun selected Taylor Instruments for an important part in the control of their synthetic glycerine process, and had the full cooperation of Taylor Field Engineers in tuning up the instruments before going on stream.

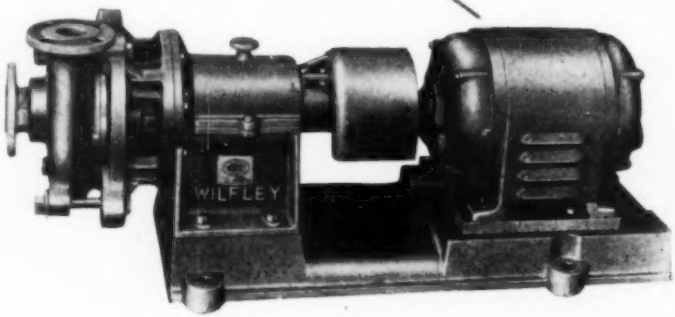
Whatever processing problems face you—from the simplest to the most complex—there's a Taylor Instrument or control system that can help you solve them. Ask your Taylor Field Engineer, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

▼ ▼ ▼

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.



Taylor Pressure and Speed Controllers for gas compressor.



for ACIDS

This is the dependable, modern acid pump that eliminates trouble in chemical production. It handles acids, corrosives, hot liquids, and mild abrasives with cost-saving efficiency. You can count on it 24 hours a day, month after month without attention. 10-to 2,000-G.P.M. capacities; 15-to 150-feet heads and higher. Individual engineering on every application. WILFLEY is the pump to buy when you want dependability PLUS lower operating costs. Write or wire for complete details.

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A. R. WILFLEY & SONS, INC.
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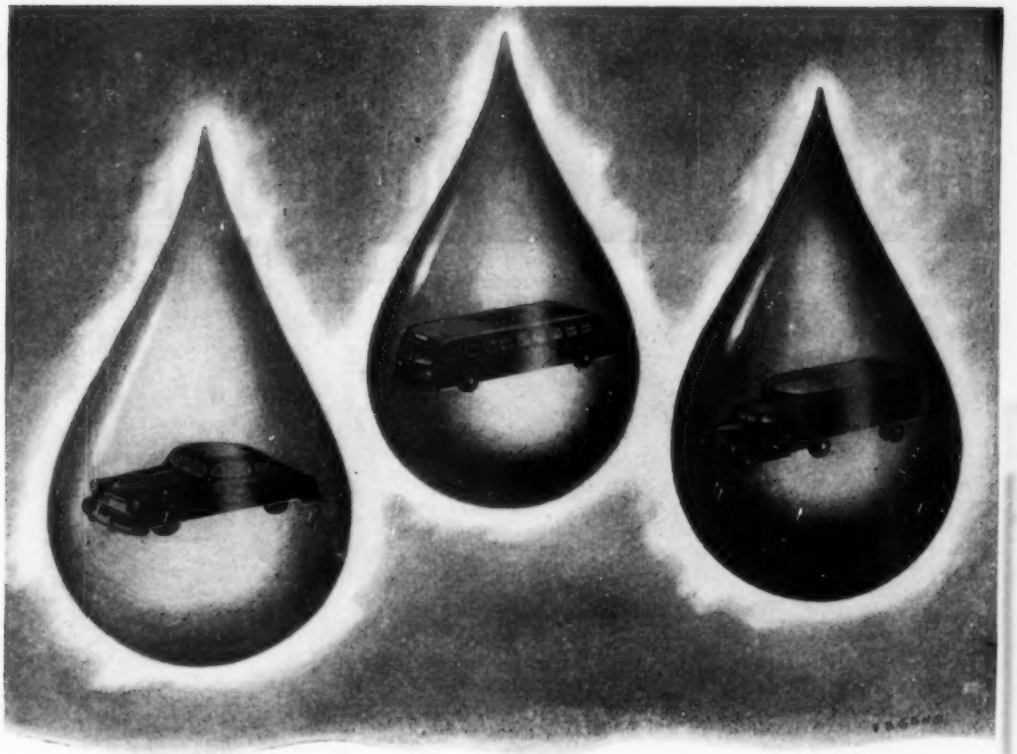

AEROLUBE ADDITIVES

...to increase your motor oil capabilities

The need for keeping a wide margin between motor oil *capabilities* and increasing lubrication *requirements* is a real challenge—not only to the petroleum industry but also to the additive suppliers.

Cyanamid helps you meet this challenge squarely with AEROLUBE* Additives . . . designed for maximum detergency, oxidation resistance and corrosion inhibition in regular, premium and heavy-duty oils . . . and proved through years of experience. Backed by Cyanamid's research laboratories, our sales and service staff will help you select the right AEROLUBE Additives to improve the properties of your motor oils at economic treating costs.

Other Cyanamid chemicals for the petroleum industry include AEROCAT* Synthetic Fluid Cracking Catalysts, AERO** Specialty Catalysts, Gasoline Dyes and Drilling Mud Chemicals. Literature and samples of these products are available upon request. Write today.

*Reg. U. S. Pat. Off.
**Trademark

AMERICAN Cyanamid COMPANY

PETROLEUM CHEMICALS DEPARTMENT, DIV. A

30 Rockefeller Plaza, New York 20, N. Y.

WHEN PERFORMANCE COUNTS . . . CALL ON CYANAMID

POWELL VALVES start their 103rd year of service to Industry

—and the Powell record of satisfactory performance throughout all the past years is your guarantee for the future.

A century is a long time to concentrate on making valves—and nothing but valves. But it's not only important *how long* you've been doing something but also *how well.*

The fact that, in all these years, Powell has never failed to produce the *right* valves to satisfy every industrial need, is real "service."

As we start our 103rd year, there's a Powell Valve of correct design *and material* for every one of your flow control requirements. And, as new conditions bring new demands, there'll be Powell Valves to meet them.

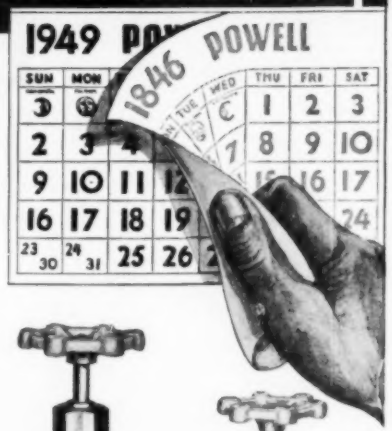

Fig. 1793—Large 125-pound Iron Body Bronze Mounted Gate Valve. Made in sizes 2" to 30", inclusive. Has outside screw rising stem, bolted flanged yoke and tapered solid wedge. Also available in All Iron for process lines.

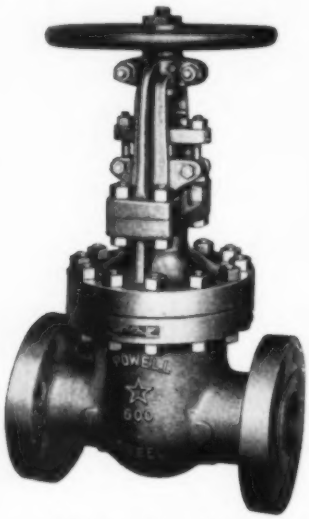

Fig. 6003—Class 600-pound Cast Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke and tapered solid wedge.

Fig. 375 — 200-pound Bronze Gate Valve. Screwed ends, union bonnet, inside screw rising stem and renewable "Powellium" wear-resisting nickel-bronze disc.

Fig. 1708 — 200-pound Bronze Globe Valve with screwed ends, union bonnet, renewable, specially heat treated stainless steel seat and regrindable, renewable wear-resisting "Powellium" nickel-bronze disc.

Fig. 3061—Class 300-pound Cast Steel Swing Check Valve with flanged ends and bolted flanged cap.

The Wm. Powell Company
Cincinnati 22, Ohio
DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES

"A Cottrell Installed by Research Corporation *will reduce catalyst loss to less than one ton per day"*

The through-put capacity of the cracking unit in the oil refinery was 20,000 barrels per day. The engineer from Research Corporation noted the plant arrangement and type of catalyst to be used and was able to recommend a Research Corporation Cottrell that would keep catalyst losses to less than one ton per day. Actually in some plants the Cottrells have, in effecting the above results, recovered as high as 50 to 100 tons of catalyst per day.

Performance like this is the result of over 35 years of experience combined with careful engineering appraisal, attention to details and a remarkably efficient method. These, combined with equipment which gives recoveries of over 99%, are responsible for outstanding records of recovery.

A letter from you to the Research Corporation will bring an informative bulletin describing HOW the Research Corporation Cottrell Electrical Precipitator performs, and HOW it can bring about important savings. Write for your copy today. RC-107

Research Corporation Installations

47 CARBON BLACK PLANTS
200 METALLURGICAL INSTALLATIONS
203 ACID PLANTS • 34 PAPER MILLS
262 DETARRING INSTALLATIONS
195 POWER STATIONS
71 STEEL PLANTS • 95 OIL REFINERIES
AND MISCELLANEOUS INSTALLATIONS

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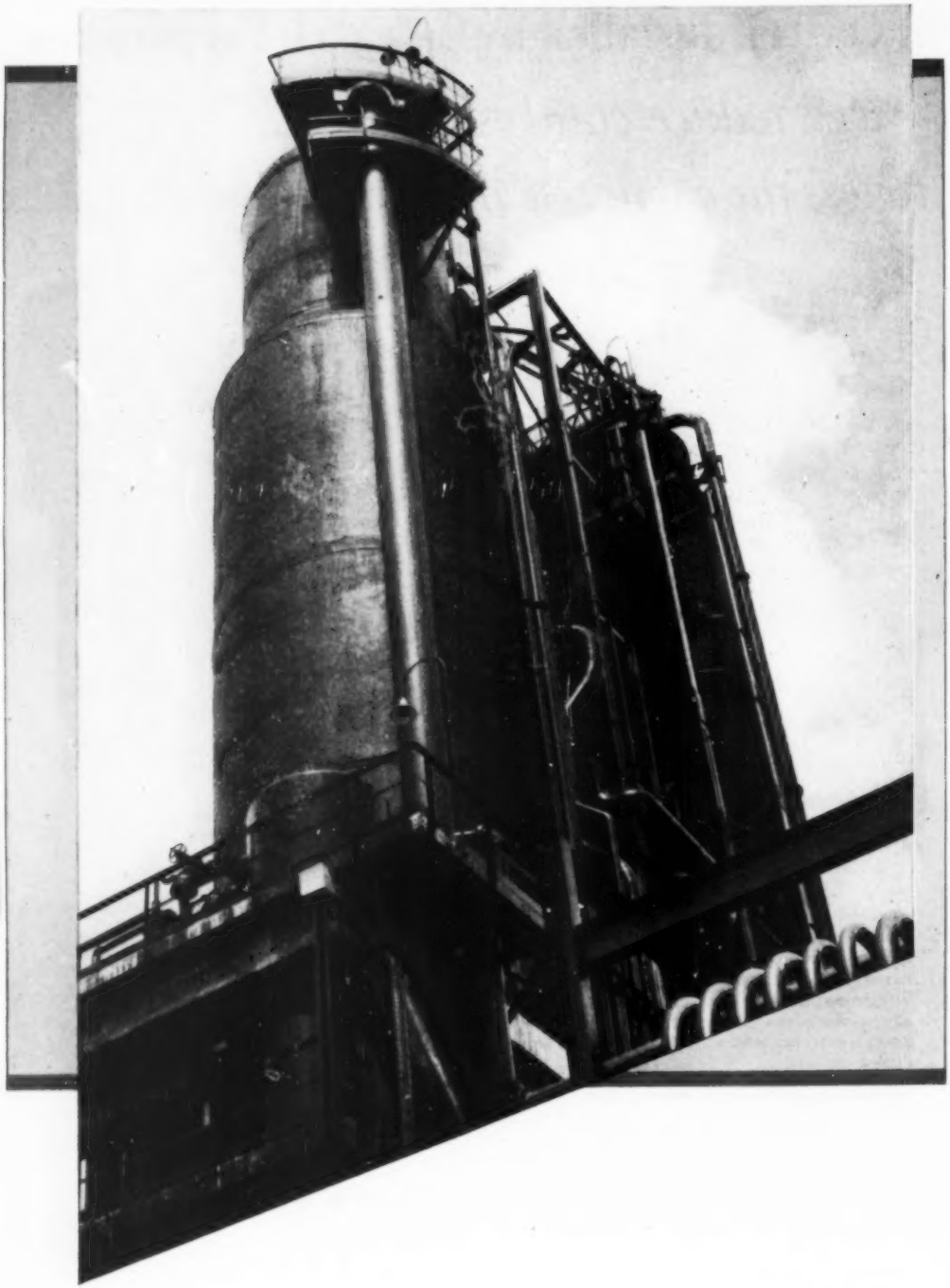


A FUNDAMENTAL COMPONENT

The efficiency of many petroleum, chemical and petro-chemical plants depends on the performance of their distillation units. Badger-built distillation units are designed for on-stream efficiency, flexibility of operation, accurate control and maximum economic yield of specification products.

The capacity of all distillation units designed and constructed by E. B. Badger & Sons Co. totals 4,500,000 barrels a day. If all these units were in the petroleum industry alone, they would provide sufficient capacity to distill over 80% of the national crude oil output.

Actually, of course, these units are at work distilling, separating and refining all sorts of chemical and petroleum products — from glycerin to gasoline, from peppermint oil to phenol, from alcohol to asphalt.

If you are planning plant expansion or new plant construction we invite you to take advantage of the broad process and engineering experience of E. B. Badger & Sons Co. to assure the fast and successful completion of your project.

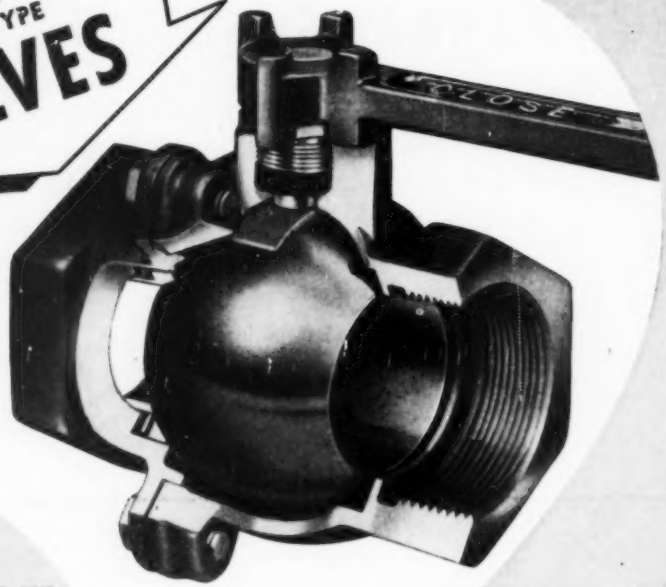
E. B. **BADGER** & SONS CO. Est. 1841

BOSTON 14 • NEW YORK • SAN FRANCISCO • LOS ANGELES • LONDON

A SUBSIDIARY of STONE & WEBSTER, INC.

NEW ROCKWOOD BALL TYPE VALVES

perform better . . . last longer!



Recommended for 300 p.s.i. working pressure

Rockwood offers you a completely new type of ball valve with these outstanding features — full round flow, leak proof service and quick opening and closing. This new Rockwood Ball Type Valve will cut your production cost, reduce maintenance cost and increase the output of materials handled.

Chrome plated floating ball shut-off resists pitting, scratching and abrasion and in combination with the synthetic rubber seat, assures pressure tight seal and longer valve life.

Available in bronze in all pipe sizes from ½" to 2", the Rockwood Ball Type Valve is recommended for service in oil refineries, food, paper, propane, chemical and rubber plants, etc.

Further information may be had upon request. Write for folder V-4.

Distributors in all principal cities.

7 OUTSTANDING FEATURES

- Full round open area — no turbulence in fluid stream
- Leak proof after continued use
- New floating ball — resists pitting, scratching and abrasion
- No exposed seating surface in open or closed position
- Easy to open or close under full pressure
- Installed in any position
- Quarter turn (90°) opening and closing valve

ROCKWOOD

ROCKWOOD SPRINKLER CO

102 HARLOW STREET WORCESTER 5, MASS

PAGE WELDING ELECTRODES AND GAS WELDING RODS

WELDING STAINLESS?

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TO RESIST WHAT?

HEAT?
COLD?
IMPACT?
BENDING FATIGUE?
CORROSION?
WHAT **KIND** OF CORROSION?

○

NOW ONE MORE QUESTION:

Are you using the best electrode or rod for your purpose?

If you're not too sure, get in touch with your PAGE distributor. Either he knows or he can find out from the PAGE Field Service Man. And the PAGE distributor has a wide selection of Page-Allegheny Stainless Steel rods and electrodes, so that he can give you the one that will serve you best.

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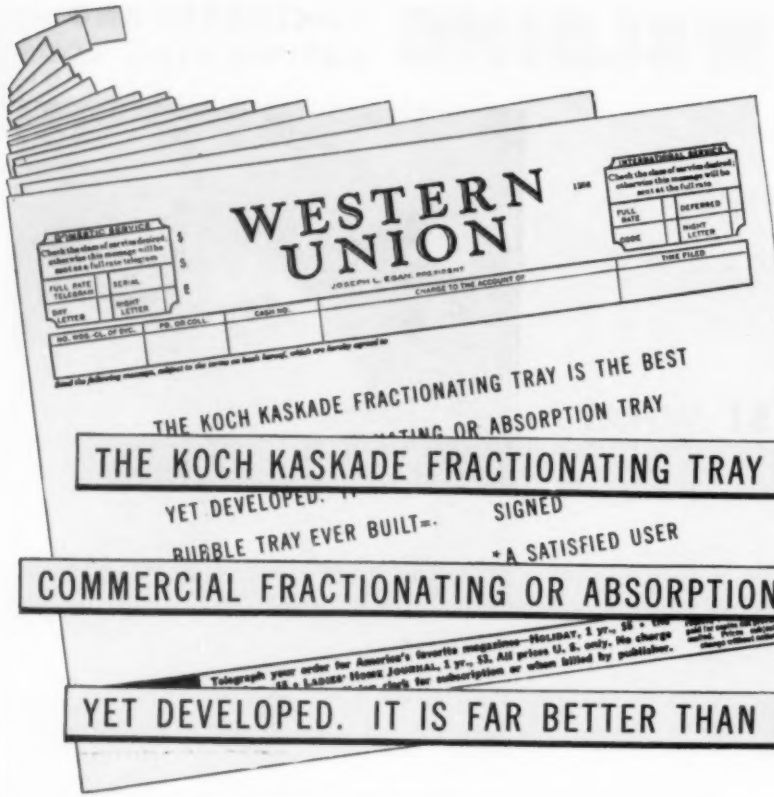
TRADE MARK

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

Get in touch with your PAGE Distributor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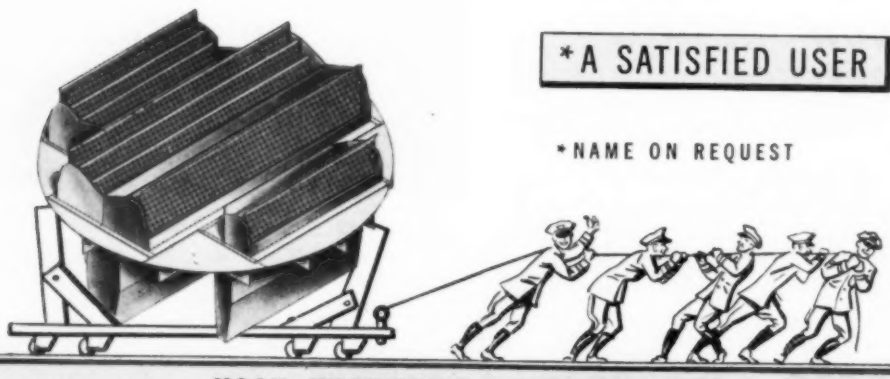
*NAME ON REQUEST



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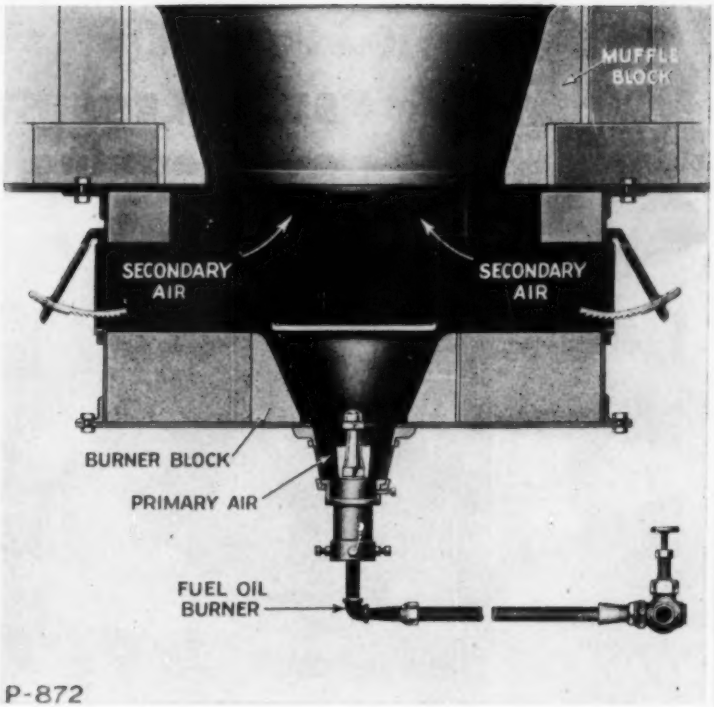
NATIONAL AIROIL FUEL OIL - GAS BURNERS



P-872

This Up-Fired Oil Burner Unit . . .

offers you 4 DISTINCT ADVANTAGES

1. Easy to light off on a cold setting with all grades of fuel oil.

2. Easy to adjust for most desirable flame characteristics throughout a wide capacity range.

3. Assures smokeless combustion with a minimum of excess combustion air and stack draft.

4. Provides stability of ignition with a bright flame to insure the maximum transfer of heat by radiation to wall tubes.

NATIONAL AIROIL BURNER COMPANY is a pioneer in the development and successful application of Up-Fired Oil Burner Units to stills and heaters. The above listed *Advantages* are time and money savers . . . can your plant afford to be without them? We will be glad to send you detailed literature.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory: 1254 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.
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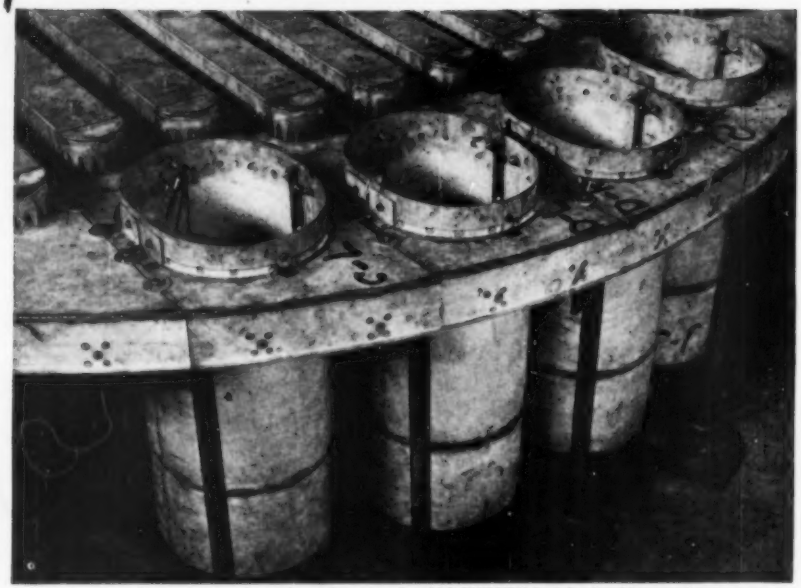
INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

"STAINLESS STEEL cuts our cleaning costs . . ."

—say plant managers



Bubble caps and trays are two of countless refinery uses in which ENDURO Stainless Steel has cut cleaning costs. Other applications for money-saving ENDURO include deck plates, truss supports, vapor risers, still linings, heat exchanger and condenser tubes, hot oil lines, valves, pumps and cracking stills and tubes.

● Faster cleanouts with less manpower is the rule where Republic ENDURO Stainless Steel is used for tower internals. ENDURO'S smooth surface is pore-free and corrosion-resistant; it discourages coking and fouling . . . washes easily and completely with a hose.

High in structural strength, ENDURO is used in thinner sections, saving space for more efficient manways to expedite pre-cleanout inspections. And, the low heat capacity of light gauge stainless steel enables the tower to go back on-stream again in a hurry.

To save on cleaning costs . . . to shorten inspection and down-time, specify Republic ENDURO Stainless Steel—manufactured in a wide range of analysis to meet every refinery need. Talk with your equipment manufacturer or write us for more information:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
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REPUBLIC STEEL

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STAINLESS STEEL

RESISTANT TO RUST AND CORROSION • RESISTANT TO HEAT • HIGH IN STRENGTH • EASY TO FABRICATE
EASY TO CLEAN • FREE FROM CONTAMINATION • EYE APPEALING • LONG LASTING • LOW ULTIMATE COST

A PRODUCT OF REPUBLIC STEEL

K&M "Century" Asbestos Corrugated

for long life without maintenance...

The "new" roof on this industrial building is actually more than 3 decades old! A coal operator installed these "Century" Asbestos Corrugated sheets on a coal tipple 33 years ago before he re-used them here.

for modern architectural effect...

Beauty in typically modern style is brought to this store with a facade of "Century" Asbestos Corrugated. This beauty will *last* without any painting or other expensive upkeep.

You've probably noticed that "Century" Asbestos Corrugated is growing in popularity for decorative motifs... inside and outside... for industrial plants, stores, restaurants, theaters. There's a rugged attractiveness in the simplicity of the corrugations and neutral light-gray coloring.

And perhaps it's no news to you that "Century" Asbestos Corrugated is thoroughly practical from the *structural* point of view. It actually *toughens* with age. Never needs to be painted. Can't rot, corrode, catch fire, or succumb to termites.

NEW "TOP-SIDE" FASTENERS CUT ROOFING COSTS

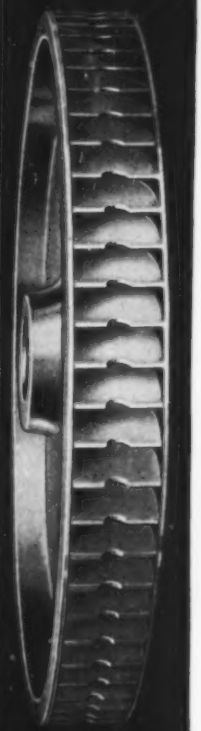
On top of all this, you can specify the new "TOP-SIDE" Fasteners, and cut a big slice off the cost of roof installation over steel purlin construction. Exclusive with "Century" Asbestos Corrugated, these new fasteners permit roofing to be done entirely from *atop the roof* ...eliminating entirely the costly labor and scaffolding normally required beneath. This feature, alone, is worth looking into—write us for full details.

Nature made Asbestos... Keasbey & Mattison has made it serve mankind since 1873

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos

TERRY



BLADE PROTECTION

Made Possible by Nozzle Location

In the Terry Solid-Wheel Turbine, the steam enters the buckets from the top, not from the side of the wheel, as shown in the illustration above. This permits a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though excessive thrust should tend to move the shaft.

This feature and others, as important, are described in detail in Bulletin S 116 which will be sent to you on request.

T-1175

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

R-S valvEvents

ISSUED PERIODICALLY BY R-S PRODUCTS CORPORATION, PHILADELPHIA 44, PA., FOR THOSE CONCERNED WITH FLOW CONTROL AND SHUT-OFF

Lots of Folks Can Make a Valve . . . .

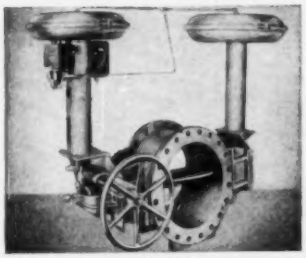
Many machinists can make a valve. They don't even have to be very good machinists, nor have very good equipment because it probably won't be a very good valve anyway. In any event it will lack the engineering a valve requires if it is to stand up and deliver the service.

Big businesses with big shops often succeed in building a valve which will give service but they pay a fabulous price to do it, though the cost is often hidden in "shop overhead." Various people concerned believe they have saved money but accurate cost-accounting would prove this not to be the case.

We recently saw a large valve built in the company shop by a manufacturer (not in the valve business) who boasted of a cost of only about $4,000. We couldn't have built the job in our own shop, specializing in valve construction, for less than $7,000, before figuring our modest profit. We know darned well no amateur valve-builder could build it for $4,000 either!

The days of the slap-happy stove-pipe damper masquerading as a valve are gone, and R-S Products with its rigid engineering standards has done much to banish them.

R-S Control and Shut-off Valves are as carefully engineered as a bridge or a building and there are just about as many stresses to figure to build a valve which will give full service with full safety factor, without waste of material or labor.



R-S Valve Type 706, 24 inch, 125 pound, with two diaphragm motors

For Regulating Downstream Pressure

R-S Valve, Type No. 706, shown at top of next column, is a 24-inch 125-pound valve with two diaphragm motors, single valve-positioner and single pressure controller. Designed for regulation of downstream pressure. The vane opens with air failure. 80-pound pressure-drop across the valve demands the use of two diaphragm tops to get the needed power.

Let's Get This Straight

Cast iron valves do not thrive in a temperature of 1400° F. Nevertheless, people ask for them occasionally. Russell Ayers, Sales Manager of R-S Valve Division, had another such inquiry recently, as reported to the Editor of ValvEvents.

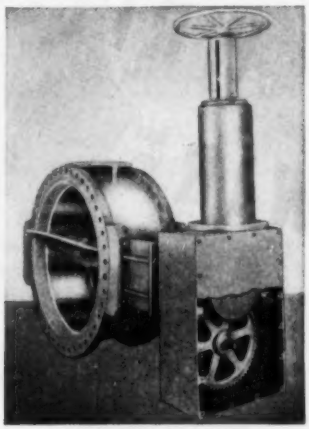
At 1400° F. a cast iron valve has long since lost all interest in flow control, not to mention shut-off.

Here's a brief rough guide on what various metals will take in the way of temperature:

Material	Elevated Temperature Limit
Cast Iron	450 deg. F.
R-S "H" Metal	1000 deg. F.
Carbon Steel	750 deg. F.
Carbon Moly Steel (½% Moly)	950 deg. F.
Chrome Moly Steel (4-6% Chrome ½% Moly)	1250 deg. F.
18-8 Stainless Steel	950 deg. F.
Chrome Nickel Alloy Steel (other than 18-8)	1250 deg. F. up to 2000 deg. F.

There are other factors just as important in the design of a valve as temperature. Therefore, we say the above is only a rough guide.

It is a good idea in addressing inquiries to us on valves to follow the list of working conditions on the inside back cover of R-S Catalog #17. If you haven't one, you'd better tell us and we'll send it.



R-S Valve Type 710, 48 inch, 125 pound, with renewable bronze liner

R-S Valve in High Head Water Service

Picture shows R-S Type No. 710. It is a 48-inch 125-pound cast iron valve with renewable bronze liner. This valve was built for water service and is now operating in a western dam under high pressure. The handwheel control has a gear reduction drive so that only 50 pounds of force is required of the operator to handle the valve even under highest pressure conditions.

The New R-S Valve Catalog #17

R-S Valve Catalog #17 is packed with information for engineers. There are over 70 halftone pictures of R-S Valves . . . working drawings of 21 types of R-S Valves with standard controls and fittings and complete dimensional data for all sizes . . . working drawings of 22 types of prime movers . . . numerous other diagrams, graphs and miscellaneous drawings. Address R-S Products Corporation, Valve Division, Philadelphia 44, Pa.

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Headquarters for the

MOST COMPLETE LINE

of DROP FORGED STEEL
VALVES, FITTINGS & FLANGES

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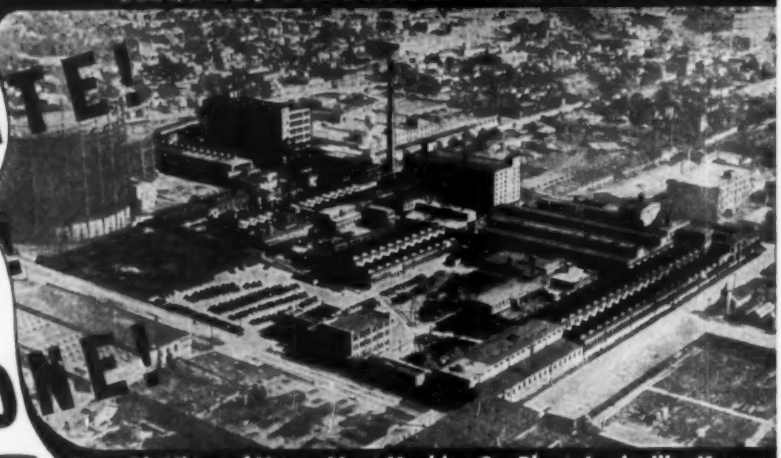

Air View of Henry Vogt Machine Co. Plant, Louisville, Ky.

Send for copy of Catalog F-8

VOGT provides one convenient, economical source of supply with the most comprehensive line of drop forged steel piping materials anywhere available to industry. Here will be found everything needed for the safe and efficient control of oil, steam, water, air, gas, and ammonia at high or low pressures and temperatures.

More drop forged steel Valves, Fittings and Flanges are made by Vogt, and deservedly so, because Vogt makes them better!

HENRY VOGT MACHINE CO.
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DROP FORGED STEEL VALVES, FITTINGS AND FLANGES

MNEMONIC FOR DRYNESS!

Remember
"ORIAD"...it means...
Oil Refinery Instrument Air Dryer.

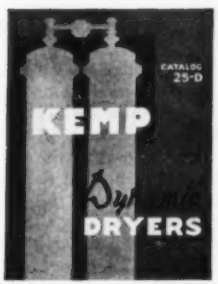
Some processes can't stand moisture . . .
Some instruments won't work when wet . . .
Some tools break down from dampness.

When you get rid of water AND water vapor you get rid of these irksome difficulties.

Kemp "Dynamic" Dryers adsorb water AND water vapor... reliably, automatically, positively, and at absurdly low cost!

You can have little portable Kemp Dryers for small rooms or local work... or great twin-tower jobs. They will dry airplane cylinders for delivery or dry air for wind-tunnels . . . to dew-points as low as −60°F.

A note on the coupon below will bring you a skilled Kemp engineer or a 48-page booklet on Kemp Dryers.



The C. M. Kemp Manufacturing Co.
405 East Oliver Street, Baltimore 2, Maryland

Please send a Kemp representative in to see me. ☐

Please send me your NEW Bulletin No. 25-D on Kemp Dryers. ☐

Name_____

Company_____

Street_____

City_____ Zone_____

State_____

CPR 2

KEMP of BALTIMORE

PRECISION CARBURETORS. BURNERS FOR INDUSTRIAL HEAT CONTROL. FIRE-CHECKS AND OTHER SAFETY DEVICES ATMOSPHERE GENERATORS. INERT GAS PRODUCERS. ABSORPTIVE DRYER SYSTEMS FOR PROCESS CONTROL.

These LIFE TESTS *prove:*

THE VALUE OF MONEL-CLAD STEEL HERE

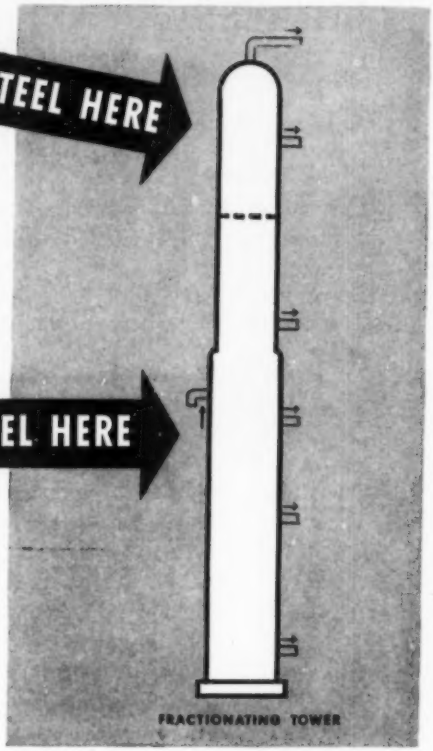
PLANT CORROSION TESTS* IN TOP OF CRUDE TOPPING TOWER	
Material	**Corrosion rate, inch penetration per year**
Monel	0.003
Nickel	0.006†
Inconel	0.017†
18-8 Mo stainless steel (type 316)	0.053†
18-8 stainless steel (type 304)	Completely corroded away

*In straight run gasoline vapor in top of tower. Average temperature 250° F. Duration of test, 60 days. West Texas crude.
†These materials suffered pitting attack.

AND OF STAINLESS-CLAD STEEL HERE

PLANT CORROSION TESTS* IN BOTTOM OF CRUDE TOPPING TOWER	
Material	**Corrosion rate, inch penetration per year**
Monel	0.17
Nickel	Completely corroded away
Inconel	0.0002
18-8 Mo stainless steel (type 316)	Less than 0.0001
13 percent Cr steel (type 410)	0.0014

*At bottom of crude fractionating tower, approximately 5' above tray No. 38 near the overflow side. Average temperature 700° F. Duration of test 120 days. East Texas crude. 88 gal. per hr. Na_2CO_3 injected into crude feed.


FRACTIONATING TOWER

Consider, first, the materials promising long life on your equipment; tests like these tell you that. Then weigh comparative cost figures, fabricating characteristics and any other factors involved. You find a safe and economical answer—the Lukens Clad Steel best meeting your requirements.

Life of equipment is lengthened many times, reducing depreciation to a fraction. Maintenance costs are held to a minimum. Equipment is kept in service without interruption. Safe operation is assured. Think what all these advantages add up to!

Lukens makes the most complete range of clad steels available from any source; Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels, in plates as wide as 178 inches or to over 3 inches thick. Each has a uniform cladding of the corrosion-resistant metal permanently bonded to the steel backing plate. All are available in the extra-smooth sodium hydride finish.

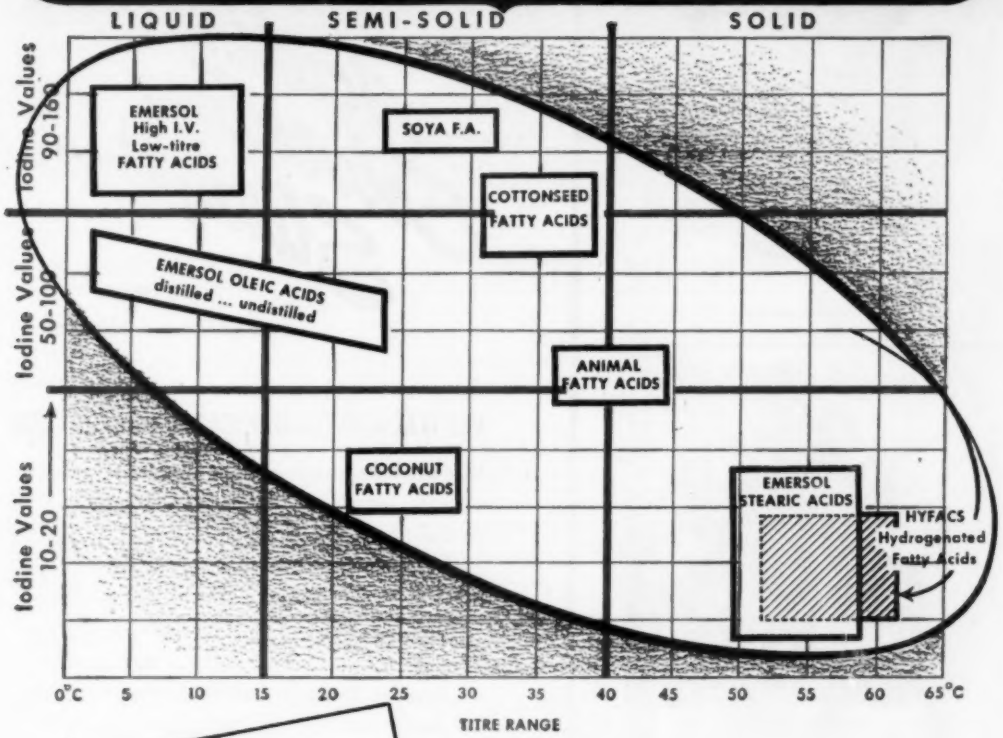
Bulletin No. 461 describes Lukens Clad Steel installations in the Petroleum Industry. For copies, write Lukens Steel Company, 404 Lukens Building, Coatesville, Pennsylvania.

LUKENS
Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

CHECK THIS CHART — See How There Is An Emery Fatty Acid For Every Use



FATTY ACID ESTERS

In general, these esters though not soluble in water, exhibit surface-active properties which make them excellent dispersive blending or softening agents. Write for Bulletin 461 containing complete specifications.

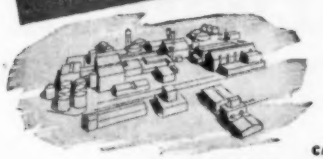
Emery 2210 Glyceryl Monostearate
2230 Glyceryl Trioleate
2510 Propylene glycol monostearate
2410 Diethylene glycol monostearate
2221 Glyceryl Mono-oleate
2301 Methyl Oleate
2302 Propyl Oleate

Emery's Development Department is evaluating the polyglycol esters withl various fatty acids. Working samples are available.

● The physical and chemical characteristics of greases are closely related to the soaps from which they are compounded. This means that the amounts and kinds of unsaturated and saturated acids present in the fatty acids from which the soap is made, play a very important part.

While the chart above is not intended to demonstrate this with mathematical precision, it does indicate how single fatty acids or blends can be selected for specific characteristics, from the range of Emery Fatty Products available.

For technical information on the use of Fatty Acids in the manufacture of solid and liquid lubricants, soluble oils and specialty compounds, write to our Sales Service Department.



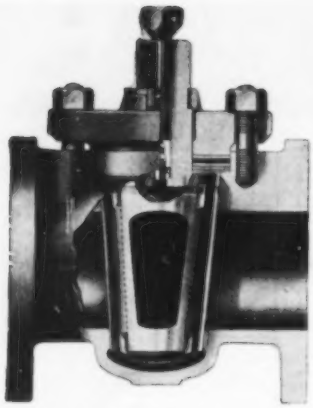
EMERY INDUSTRIES, INC.

FATTY ACIDS

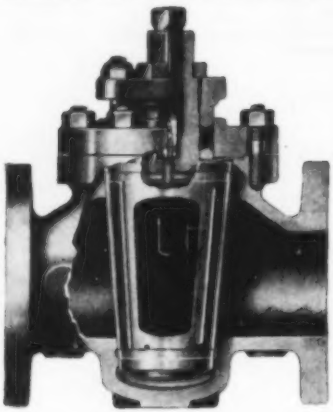
CAREW TOWER • CINCINNATI 2, OHIO

3002 Woolworth Building, NEW YORK 7, N. Y.
187 Perry Street, LOWELL, MASSACHUSETTS
401 N. Broad Street, PHILADELPHIA 8, PA.

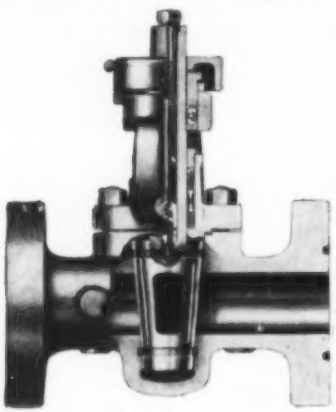
STEARIC ACID • OLEIC ACID • ANIMAL AND VEGETABLE FATTY ACIDS • TWITCHELL PRODUCTS • PLASTICIZERS



Single Gland Type



Regular Gland Type



Ball Bearing Type

FOR HANDLING

Acids... Solvents... Sludges...

and other troublesome liquids—

USE WALWORTH LUBRICATED PLUG VALVES

When handling acids, condensates, dyes, oils, solvents, solutions, slurries and hundreds of similar "troublesome" liquids, you get better control, more dependable service and lower operating costs with Walworth Lubricated Plug Valves.

These valves have proved their ability to give easy operation . . . fast action . . . tight shut off . . . greater protection against corrosion. Turning is smooth and easy; just a ¼ turn from full-opening to full-closing. Moreover, Walworth Lubricated Plug Valves are tightly sealed against leaks — *whether open or shut.*

Walworth Lubricated Plug Valves are available in sizes ½" to 26" for pressures from 125 to 5,000 psi, and for vacuum requirement. For further information about Walworth's Complete Line of Lubricated Plug Valves, see your Walworth distributor or write for Catalog No. 46L.

WALWORTH

valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

NH_3 $NaOH$ $NaCl$ H_2SO_4 H_2S

HOW SELLERS VALVES CONTROL THESE SEVERE CORROSIVES...

HCl HF

New positive shut-off valve gives continuous operation...

Five years ago, the Sellers Injector Corporation installed the first of their new valves for controlling harsh chemicals used in petroleum processes.

Since then, over 1,200 have been put into service . . . 1,200 positive shut-off valves in lines carrying corrosives from hydrofluoric acid to brine.

Performance? The Sellers Injector Corporation can show you proof that only 4 per cent have required minor repairs. And—*in every case*—positive shut-off was obtained when required.

Let's look at one of these valves in HF service:

The body and bonnet are cast steel, but all the other vital parts—*stem, plug, seat, back seat, lubricators, lock nuts* and *packing glands*—are MONEL*.

This liberal use of Monel is important. In hydrofluoric acid service, for example, those Monel parts were subjected to a constant boiling mixture at 230-300° F. under pressures of 75-110 psig. At the end of 5 years, they were still on the job!

And Monel withstands such commonly-met corrosives as sulfuric acid, caustic soda, hydrogen sulfide, anhydrous ammonia, salt water and brine—and dilute concentrations of hydrochloric acid which result from electrolysis of brine in crude.

For complete information about Sellers Monel-trimmed Positive Shut-off Valves and their special, easy maintenance features, write *Sellers Injector Corporation*, 1600 Hamilton Street, Philadelphia 30, Pa. *Reg. U.S. Pat. Off.

THE SELLERS MONEL-TRIMMED VALVES *described in the accompanying text are designed to provide the flow characteristics of gate valves, the facility of repairing globe valves, and the positive shut-off of properly functioning plug cock valves.*

• • •

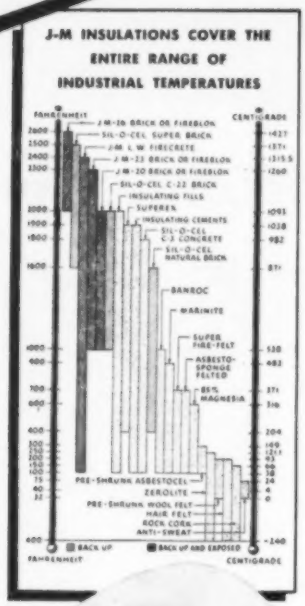
MULTIPLE SEATING SURFACES *assure greater tightness, longer life and increased dependability. Sellers Monel-trimmed valves are also provided with a bottom pocket which acts as a trap for entrained solids and corrosion products. This not only protects the valve, but downstream equipment as well.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
INCO
TRADE MARK

MONEL...*Your Partner in Progress*

Facts about J-M Insulations Subject: MATERIALS



The RIGHT Insulation helps industry offset higher fuel costs

TODAY'S higher fuel costs emphasize the importance of insulation more than ever before.

Average price at the mine for bituminous coal in 1931 was $1.54 per ton. In 1946, the most recent figure published, industry paid $3.44 per ton, and today the average price is estimated at more that $4.

Industry must choose the RIGHT Insulation to offset these higher costs. Any insulation will save *some* money. Only the *right* insulation, specifically engineered for a specific job, will save the most money for the longest period of time.

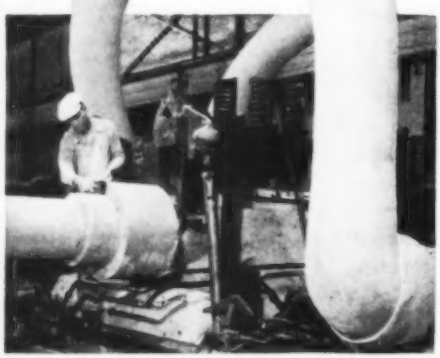
Special Insulating Problems solved with Special Materials

No single raw material will produce an insulation that operates efficiently under all industrial service conditions. That is why Johns-Manville manufactures many insulations from many selected raw materials. Johns-Manville is constantly developing and testing new insulations . . . to meet special industrial problems and to anticipate future needs of industry.

J-M insulations, made from asbestos and other raw materials, span the entire range of temperatures from 400°F. below zero to 2600°F. above. On the job, they provide that right combination of physical and thermal properties so essential for proper application and maximum fuel savings.

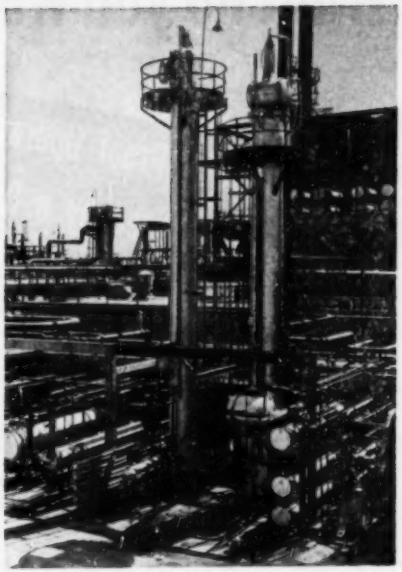
Forming a link between you and Johns-Manville Insulation Research is a network of contracting firms specializing in the practical use of J-M Insulations. First, their insulation engineers choose the type and thickness of materials best suited to your needs. Next, skilled mechanics in their employ assure efficient, economical application.

For complete details and answers to your special insulation problems, write Johns-Manville, Box 290, N. Y. 16, N. Y.



Skilled mechanics applying canvas jacket over J-M 85% Magnesia.

Johns-Manville *First in* INSULATIONS



SOUR CRUDES are an asset!

Many of the complex sulphur problems, arising from the necessity of using sour crudes, are being solved and brought under control by Girdler engineers. GIRBOTOL plants . . . some in operation for almost twenty years . . . are most effective for the removal of hydrogen sulphide from refinery gas, butane, propane, poly-feed stocks and gasoline. Operation is automatic, trouble-free and low-cost.

Take a tip from this whether you are in petroleum, natural gas, chemical or one of a dozen other fields where gaseous and liquid hydrocarbons need "cleaning up." Elimination of corrosion problems alone may pay the way.

Girdler's proved, progressive process design, engineering, and plant construction have combined *effectiveness* and *economy* in many problems involving industrial gases, gaseous and liquid hydrocarbons and organic compounds.

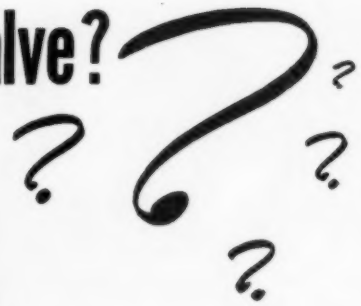
THE *GIRDLER* CORPORATION

Gas Processes DIVISION

LOUISVILLE 1, KENTUCKY

District Offices:
150 Broadway, New York City 7
2612 Russ Bldg., San Francisco 4
311 Tuloma Bldg., Tulsa 3

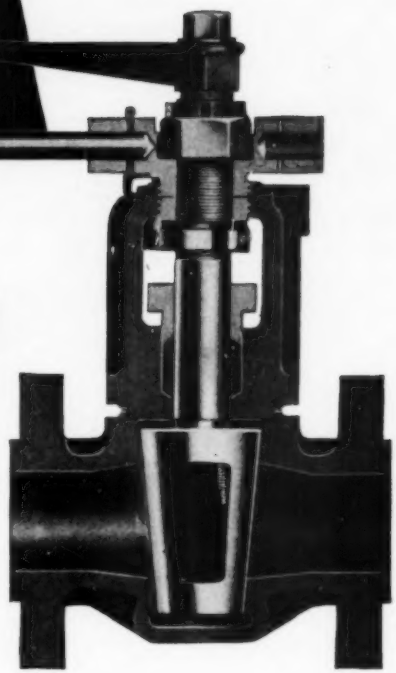
What do you want in a Valve?



✓Instant Stick Proof Operation?
✓Opened or Closed by a Quarter Turn?
✓Positive Seal without lubrication?
✓Protected Seating Surfaces?
✓Unobstructed Straight-Line Fluid Flow?

Then you want

HOMESTEAD *LEVER-SEALD* VALVES



Built into each valve is a powerful lever-and-screw device that prevents sticking and assures positive action at all times and under all conditions. Corrosive or viscous fluids, extremes of temperature or pressure or other adverse operating conditions that cause ordinary valves to fail cannot affect Homestead Lever-Seald Valves.

Operation is simple and easy. Seating pressure is first relieved with the lower lever just enough to overcome friction. Then a quarter-turn of the upper lever fully opens or closes the valve. Full seating pressure is again applied with the lower lever to make a positive, leakless seal. They operate faster, too . . . 16 to 28 times faster than screw-stem-type valves. The quarter-turn principle makes them ideal for installation in restricted areas, next to walls, floors, ceilings, congested piping and other obstructions where many other types of valves could not be operated.

Homestead Lever-Seald Valves are available in combinations of metals and alloys to meet your service requirements. Sizes range from 1¼" to 10" for pressures from vacuum to 1500 pounds.

For complete details write for Valve Reference Book No. 38 . . . today.

HOMESTEAD *LEVER-SEALD VALVES*

HOMESTEAD VALVE MANUFACTURING CO. · P. O. BOX 16, CORAOPOLIS, PENNA.

CHEMICO *has the experience in the design and construction of*
SYNTHETIC AMMONIA PLANTS

"There is no substitute for experience." That's particularly true when it comes to designing and constructing plants for the production of synthetic ammonia. For more than twenty years Chemico, utilizing the well known N. E. C. Process, has been the leading builder of this type of installation.

Today, Chemico helps in the fight to feed the world by designing and supervising the construction of complete plants for the production of nitrogenous fertilizer.

IN INDIA . . . 350,000 tons a year of ammonium sulfate will be produced by a plant at Sindri to be operated by the Indian government.

IN EGYPT . . . every day 550 tons of calcium nitrate will flow from the great plant at Suez . . . to be built for the Societe Egyptienne d'Engrais et d'Industrie Chimiques (S. A. E.).

IN MEXICO . . . 70,000 tons of low-cost ammonium sulfate will flow from a new plant near Mexico City to be built for Guanos y Fertilizantes S. A., Mexico's leading fertilizer manufacturer.

In other strategic places throughout the world—as well as in the United States—Chemico is helping to meet the need not only for fertilizer, but also for sulfuric acid, synthetic ammonia, synthetic methanol and other heavy chemicals.

In each of these projects the Chemico organization functions as Architect-Engineers in charge of design, procurement of equipment, supervision of construction, training of personnel and initial operation.

Chemico's extensive experience in these and hundreds of other installations is your guarantee of performance . . . your assurance of economical and efficient operation.

CHEMICAL CONSTRUCTION CORPORATION

EMPIRE STATE BUILDING, 350 FIFTH AVENUE, NEW YORK 1, N. Y.

European Technical Representative: Cyanamid Products, Ltd., Brettenham House, Lancaster Place, London W. C. 2, England

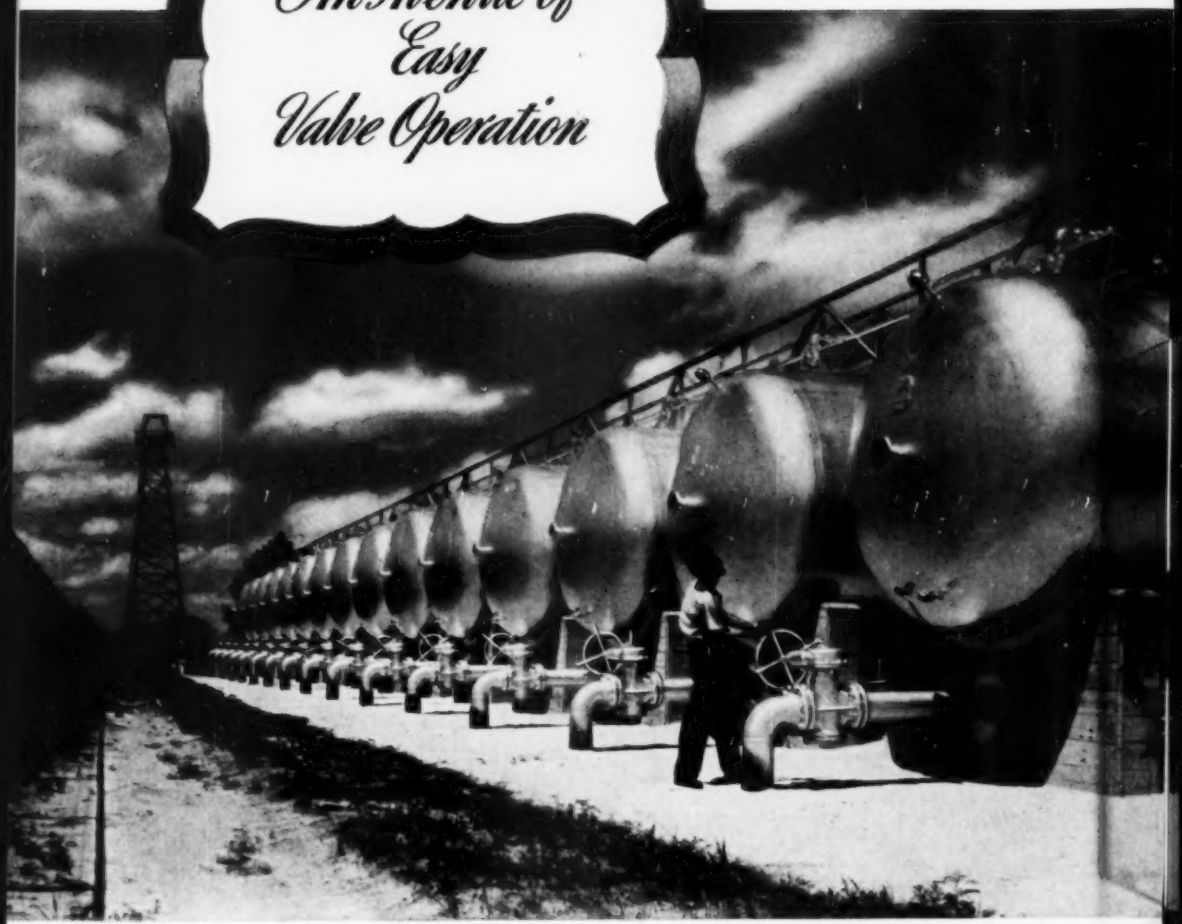
European Licensee of N. E. C. Process: Hydro-Nitro S. A., 8 Quai du Cheval Blanc, Geneva, Switzerland

Cables: Chemiconst, New York

CHEMICO PLANTS ARE PROFITABLE INVESTMENTS

Precision Produced
...from Globe Seamless Steel Tubes to Globe Welding Fittings
Your preference for Globe Welding Fittings is supported by a source of supply with exceptional qualifications. Specialized metallurgical experience and facilities gained in years of steel tubing manufacture enable Globe to produce welding fittings by a precision process that yields a superior product.
Send for the Globe Welding Fittings Catalog.
GLOBE
GLOBE STEEL TUBES CO.
Milwaukee 4, Wisconsin
Producers of Globe seamless stainless steel tubes — Gloweld welded stainless steel tubes — carbon — alloy — seamless steel tubes — Globeiron seamless high purity ingot iron tubes — Globe welding fittings.
GLOBE
PRECISION PROCESS
WELDING FITTINGS

An Avenue of Easy Valve Operation



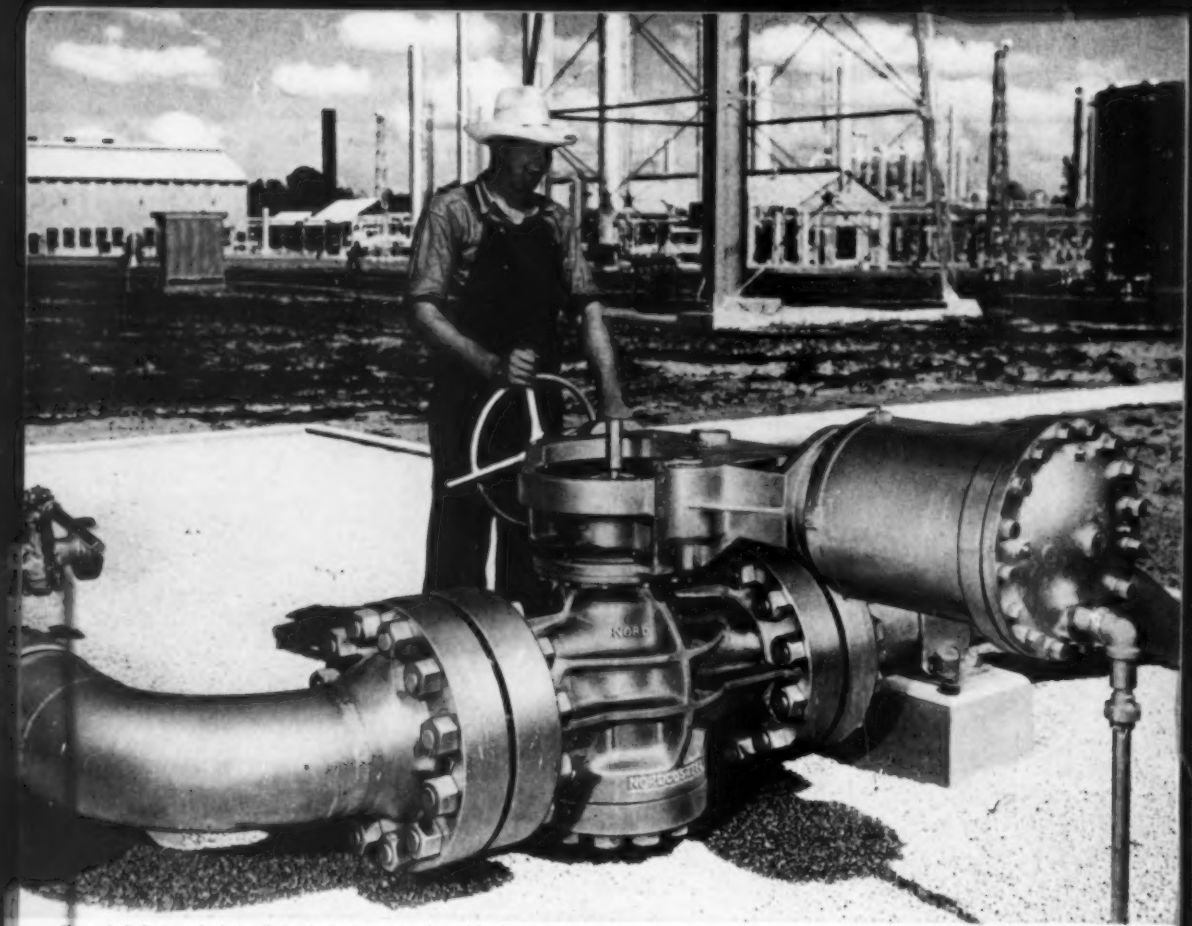
YOUR tanks may not be butane tanks like those in the picture, but they need safe, easily-operated valves just as much, no matter what they hold. Exposed to the elements, Nordstrom valves are weatherproof.

Their simple quarter-turn is time-saving, especially where there's a long row to operate. But more important, Nordstroms will not stick or gall, leak or corrode. The tapered rotary plug, seated on a film of lubricant, turns easily. A thin coating of lubricant, injected under pressure higher than that of the line, seals each port against leakage. Nordstroms are the *best* valve equipment for your lines.

Use *genuine* Nordcoseal lubricants.

Nordstrom

LUBRICATED VALVES

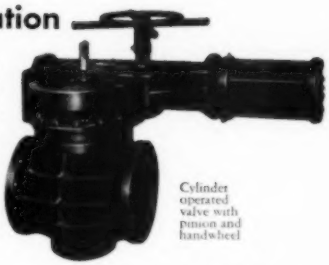


Hopeseal cylinder operated valve installation, showing manual operation with handwheel.

Remote Control or Hand Operation

Cylinder operated valve with screw stem, bevel gears and handwheel

For both power control and hand operation, there's a full range of cylinder equipped Nordstrom valves. The design permits panelboard control from a remote central point or local manual operation. Air, gas, oil, water, and in many cases fluid in the main piping system, may be used as the operating medium. Electric motor operating units can also be furnished. Nordstrom field engineers everywhere can give you full details.



Cylinder operated valve with pinion and handwheel

Keep Upkeep Down
Use *genuine*
Nordcoseal lubricants

Nordstrom LUBRICATED VALVES

ROCKWELL

Sealdport Lubrication

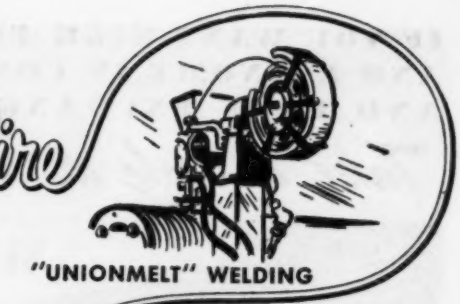
NORDSTROM VALVE DIVISION–***Rockwell Manufacturing Co.***– 400 No. Lexington Ave., Pittsburgh 8, Pa.

Atlanta • Boston • Chicago • Houston • Kansas City • Los Angeles • New York • Pittsburgh • San Francisco • Seattle • Tulsa • and leading Supply Houses

Export: Rockwell International Corporation, 7701 Empire State Bldg., New York 1, N.Y.

HASTELLOY Alloy Wire
TRADE-MARK

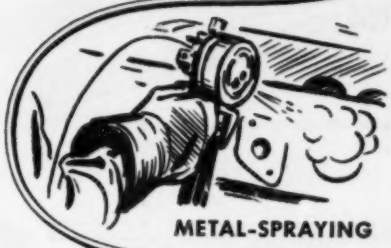
FOR METAL-SPRAYING, WELDING, and FABRICATED WIRE PRODUCTS



"UNIONMELT" WELDING

HASTELLOY nickel-base alloys, in the form of drawn wire, are available for the fabrication of corrosion-resistant screen, cloth, and baskets. The wire is also excellent for metal-spraying and for many types of automatic welding and hard-facing.

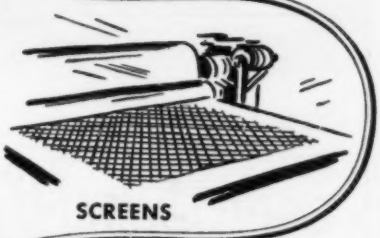
HASTELLOY alloys have a tensile strength comparable to that of the high-strength alloy steels, and possess unusual strength even at elevated temperatures. These alloys are specially designed to withstand the most severe conditions of chemical corrosion. Nickel-molybdenum alloy B is particularly resistant to hydrochloric and sulphuric acids, many organic acids, and all alkalies. Alloy C, a nickel-molybdenum-chromium-tungsten-iron composition, has excellent resistance to strong oxidizing agents, such as ferric chloride and wet chlorine, and is outstanding in its resistance to brine and salt spray.



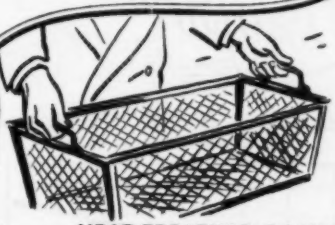
METAL-SPRAYING

In addition to HASTELLOY alloy wire, you can also obtain wire made of MULTIMET alloy—a cobalt-chromium-nickel composition developed for service at elevated temperatures.

Cut and straightened lengths or coils, in diameters down to 0.060 in., can be obtained directly from Haynes Stellite Company, Kokomo, Indiana. Wire in diameters less than 0.060 in. down to 0.002 in. is available from an associate company, Kemet Laboratories Company, Inc., Madison Avenue and West 117th Street, Cleveland 1, Ohio. For more complete information, write for a copy of the booklet, "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys."



SCREENS



HEAT-TREATING BASKETS

HAYNES
TRADE-MARK
Alloys

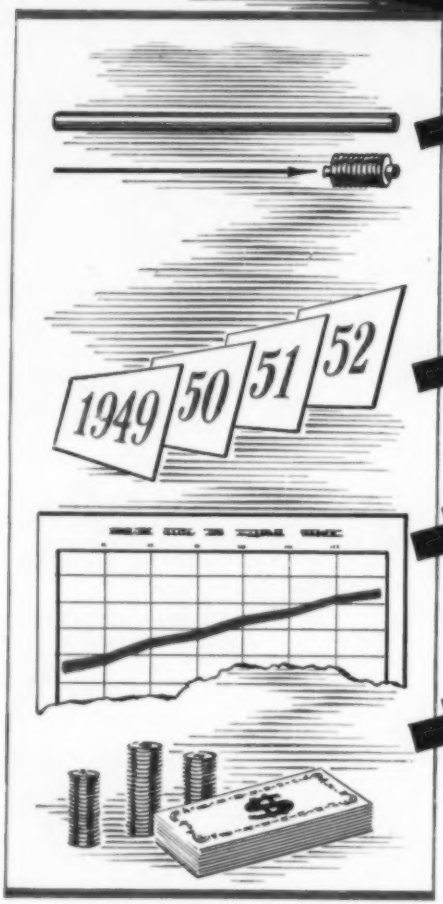
The terms "Haynes," "Hastelloy," "Multimet" and "Unionmelt" are trade-marks of Units of Union Carbide and Carbon Corporation.

Haynes Stellite Company
Unit of Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago—Cleveland—Detroit—Houston
Los Angeles—New York—San Francisco—Tulsa

IF YOU WANT HIGH EFFICIENCY AND ECONOMY IN CONDENSER AND HEAT EXCHANGER OPERATIONS . . .

Take a look at the Advantages of

WOLVERINE TRUFIN



SPACE SAVING

Trufin will give you 7 to 9 times as much surface area as the equivalent length of plain tube (depending, of course, on the fin height, spacing and diameter). That means that the required surface area can be accommodated in about one-eighth the space when Trufin is used.

LONGER LIFE

Trufin doesn't require frequent replacements. The fins being integral with the tube itself, Trufin will withstand vibration and sudden heat changes.

HIGHER EFFICIENCY

The above-mentioned features are distinctive enough for you to recognize the high potential performance of Trufin. The integral construction of the fins eliminates any possible heat loss between tube and fin.

GREATER ECONOMY

Because only a fraction of Trufin length is required to deliver the equivalent surface area in plain tube—and because Trufin assures longer life and performs at such high efficiency, the economies in using this unique tube are obvious.

WOLVERINE TUBE DIVISION
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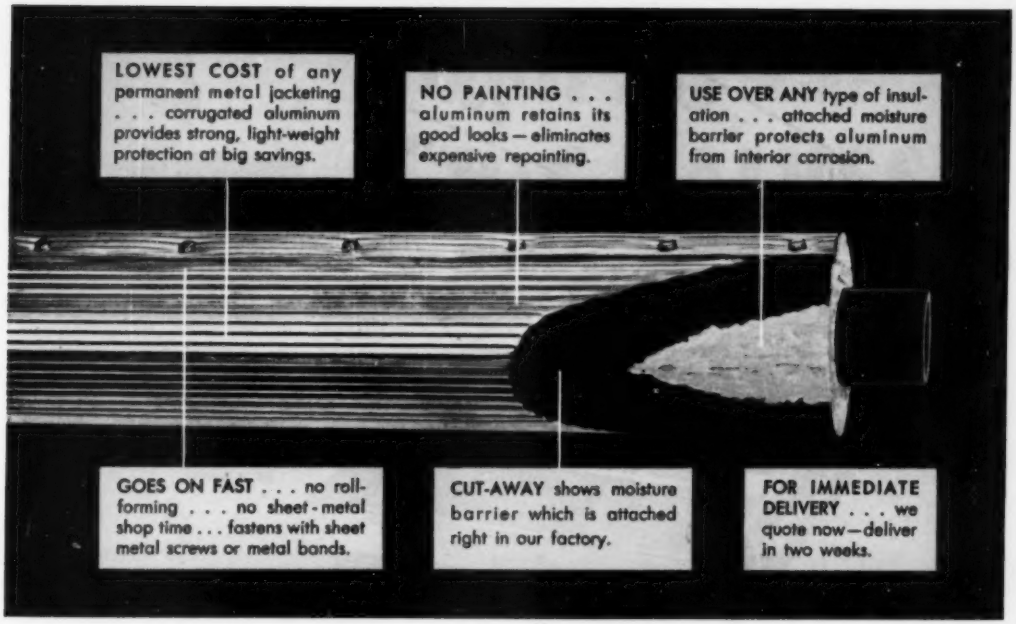
LOWEST COST of any permanent metal jacketing . . . corrugated aluminum provides strong, light-weight protection at big savings.
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GOES ON FAST . . . no roll-forming . . . no sheet-metal shop time . . . fastens with sheet metal screws or metal bands.
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NOW — Childers Jacketing gives you the weather-toughness of aluminum in a low-cost, easy-to-handle form. It requires no painting, it's weather-proof, it improves plant appearance, it comes complete with moisture barrier, and it's permanent.

And it gives you two big cost-saving advantages over other metal jacketing. Your first saving is provided by our glued-on moisture barrier. Metal jacketing needs a moisture barrier between it and the insulation. Using Childers Jacketing with the moisture barrier already attached, you cut and apply both jacketing and barrier all in one piece . . . in one operation instead of two.

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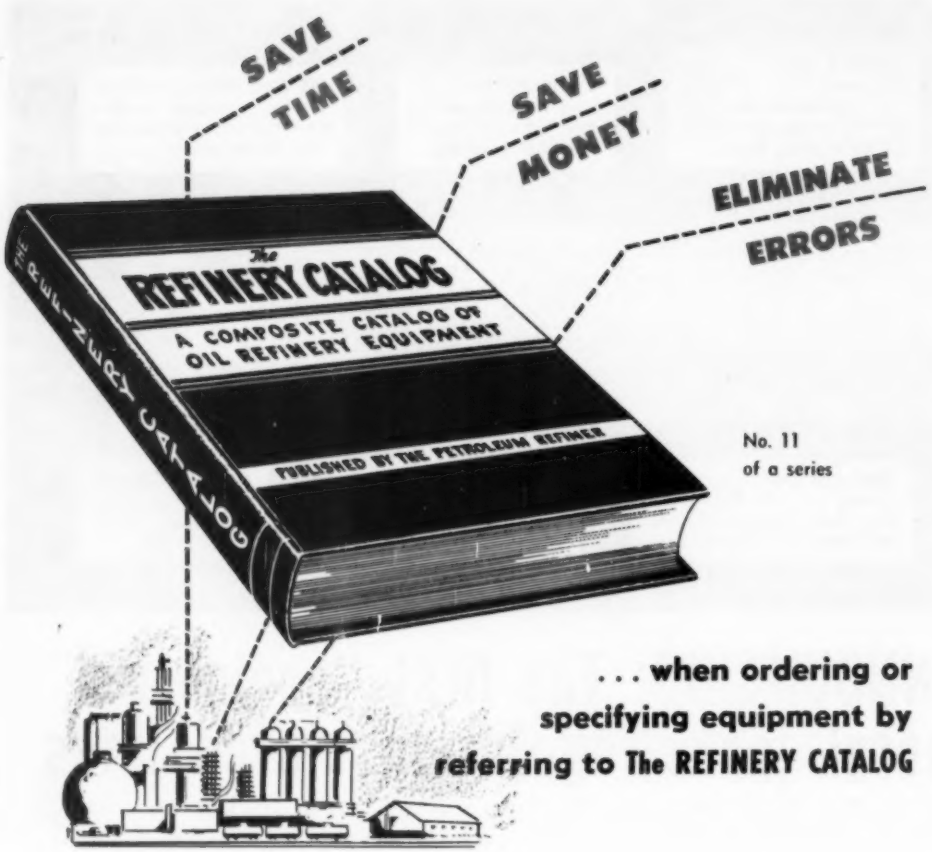

No. 11
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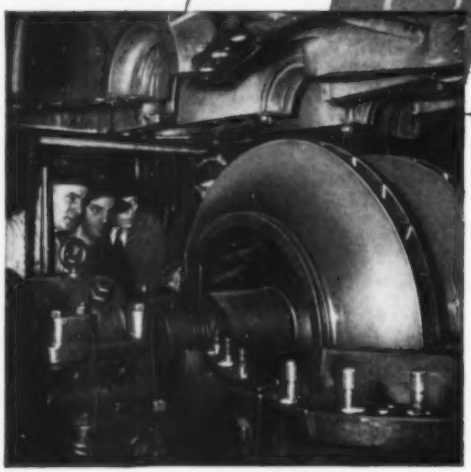
All junction points become smooth fillets, eliminating corners or crevices where (as with riveted construction) dirt may collect and cause unbalance, corrosive elements lodge and start attack.



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Accurate—Convenient—Versatile...and Low Priced

Note simplicity of controls. Also note the sloping panel that permits easy readability of scales from both sitting and standing positions.

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Interchangeable photocells—red or blue-sensitive to utilize the high resolving power of the Model "B".

Easily-attached Model "B" accessories will be available for special types of measurements and for added convenience and accuracy. Write for details.

The new Model "B" Spectrophotometer is by far the outstanding routine instrument available. It provides advancements pioneered in the Beckman Quartz and Infrared Spectrophotometers but never before offered in a low priced instrument. These advantages are important because they combine simplicity, convenience and versatility without sacrificing accuracy and reliability.

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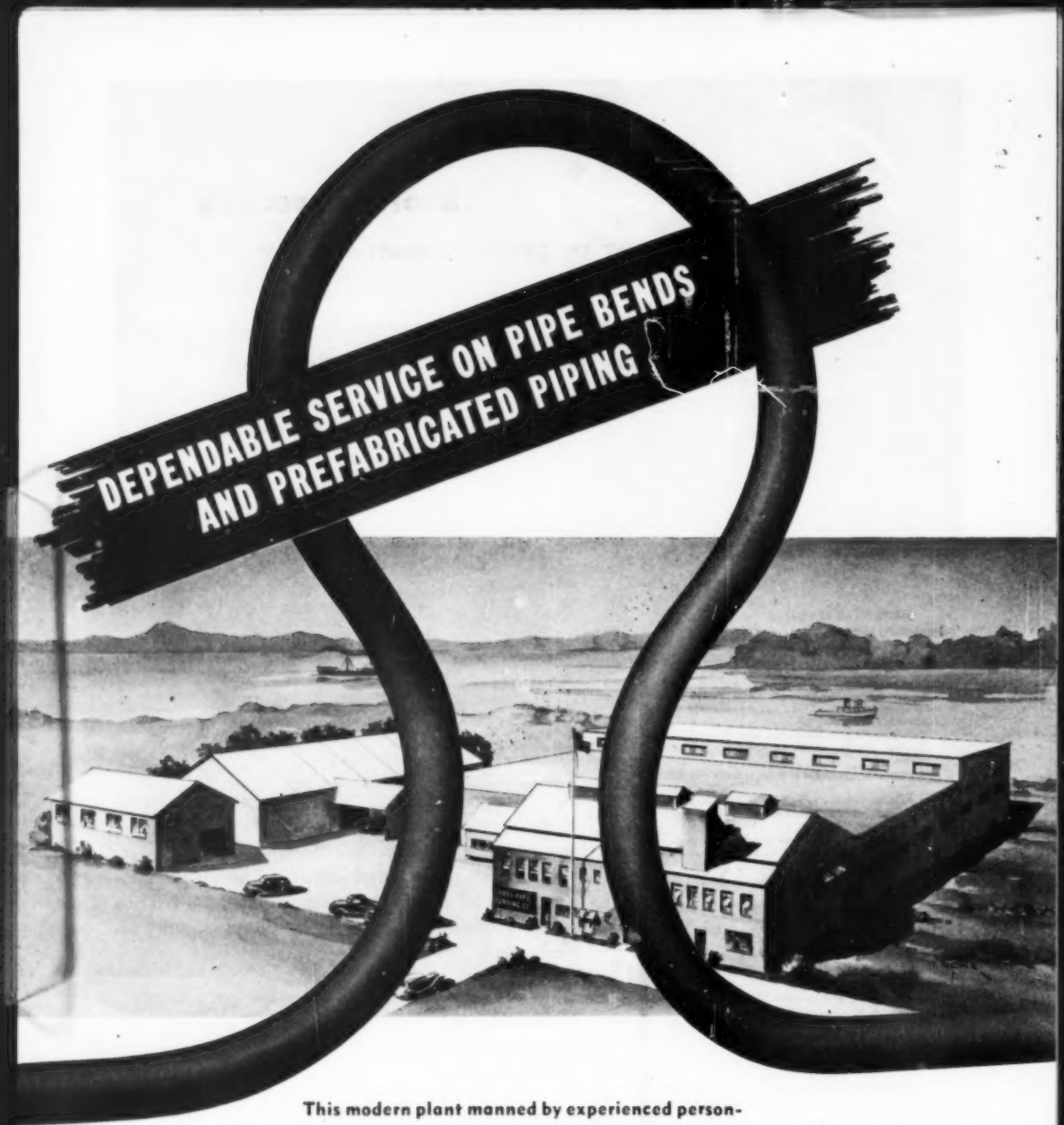

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HERE'S MONEY SAVING NEWS

for Compressor Plant Operators and Designers

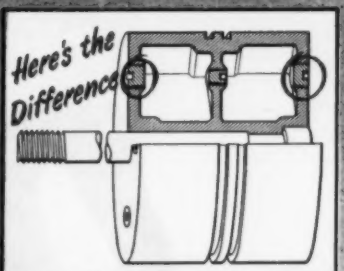
Most economical method of changing the volumetric efficiency of your reciprocating compressors

$ How would you like to save $79,000?

The simple new clearance pocket compressor piston has already done that in one gasoline plant. Here's how it happened. Thirty-five 250 HP twin compressors were in use with 17" x 20" Clark type "S" cylinders. Increasing operating pressure would formerly have required the installation of replacement compressor cylinders at a cost of $90,000 to $100,000. Installation of the new clearance pocket pistons gave the desired operating results at a cost of only $11,000 — *a clear saving of at least $79,000!*

The installation of these new clearance pocket pistons provides you with ten worthwhile advantages whether your anticipated operating pressure is *higher* or *lower* than at present:

1. **Allows you to install compressor cylinders of maximum displacement to take your gas at the lowest anticipated suction pressure.**
2. **Allows you to utilize your present cylinders and reclaim your old cylinders which have no provision for added clearance.**
3. **Allows you to change your volumetric efficiency over an exceptionally wide range.**
4. **Allows you to keep your power end fully loaded at all times.**
5. **The clearance pockets require no maintenance.**
6. **Permits easy, rapid changing of cylinder clearance by changing plugs through valve ports. Time required — only a few minutes.**
7. **The variable clearance is *inside* the cylinder, not external.**
8. **Added clearance is practically 100 percent effective.**
9. **Added clearance is in both head and crank ends of your cylinder. No vibration is induced by uneven pumping load.**
10. **Best of all, these advantages are yours at a small fraction of the cost of changing cylinders or adding compressors.**



Sketch shows cutaway clearance pocket piston. Note the main central web dividing the piston interior into two chambers. Each of these main chambers is subdivided into four pockets. Opening or closing these with plugs in piston heads varies compressor cylinder volumetric efficiency. Clearance pockets are ideally located for efficient loading and unloading.

Clearance pocket pistons are available with new cylinders or as replacement pistons from:

Clark Brothers Company
Olean, New York

The following shops are licensed to manufacture the pistons locally. They can furnish clearance pocket pistons to fit any cylinder of any make, size or type in which the piston is large enough to accommodate the pockets.

Baash Ross Tool Company — Pampa, Texas, and Los Angeles, Calif. Oklahoma City, Okla., and Houston, Texas

Midwest Machine Company — Oklahoma City, Okla., and Odessa, Texas

Eureka Tool Company — Oklahoma City, Okla.

For additional information address:

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PETROLEUM
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VOLUME 28, NO. 1 JANUARY, 1949

The LOOK BOX

AN EXCEPTIONAL growth of an non-profit technical association to meet a specialized need is that of the National Association of Corrosion Engineers (NACE). Started in 1944 by only a dozen pipe line engineers who sought to do something about the enormous loss industry is suffering through corrosion, the association in 4½ years has grown to include more than 1400 active members and 190 company members.

Joint Effort Vs. Corrosion

The active members include principally engineers working on corrosion problems employed by companies in 32 industries, by various federal, state and municipal agencies, and by the military services, universities and engineering consultants. The zeal of this group is evident. Last April nearly two-thirds of the enrolled members attended the Annual Conference and Exhibit in St. Louis, and each of the 44 papers there presented was heard by an average of 325 members.

The company members include corporations in 18 industries with such representative ones (parent or subsidiaries) as Bell Telephone System, U. S. Steel and Bethlehem, Esso Standard Oil and Socony-Vacuum, Consolidated Edison of New York and Pacific Gas & Electric, General Electric and Westinghouse, Missouri Pacific Railroad, Union Carbide & Carbon and Allied Chemical & Dye, Alcoa and International Nickel, Pittsburgh Plate Glass, Johns-Manville, Chicago Bridge & Iron, Dresser Industries, Ebasco Services, The Lummus Company, Southland Paper Mills, Honolulu Board of Water Supply, Oliver United Filters, Freeport Sulphur, Black-Clawson, Lane-Wells, and others.

The managements of these corporations are recognizing that the economic losses of corrosion include not only the immediate plant repairs or renewals but also corrosion-caused production or service interruptions, commodity losses or spoilage, curtailed revenues, accidents, fires, personal injuries or deaths, public property damage, customer and public inconvenience, and employe, customer and public ill-will.

NACE operates on the premise that solving corrosion problems requires the pooling of experience as well as the conduct of research; thus, the more—and more diversified—corrosion experience that can be pooled and disseminated, the greater and quicker will be the benefits to all who seek to stop corrosion and its economic losses.

Capitalism Does It Better

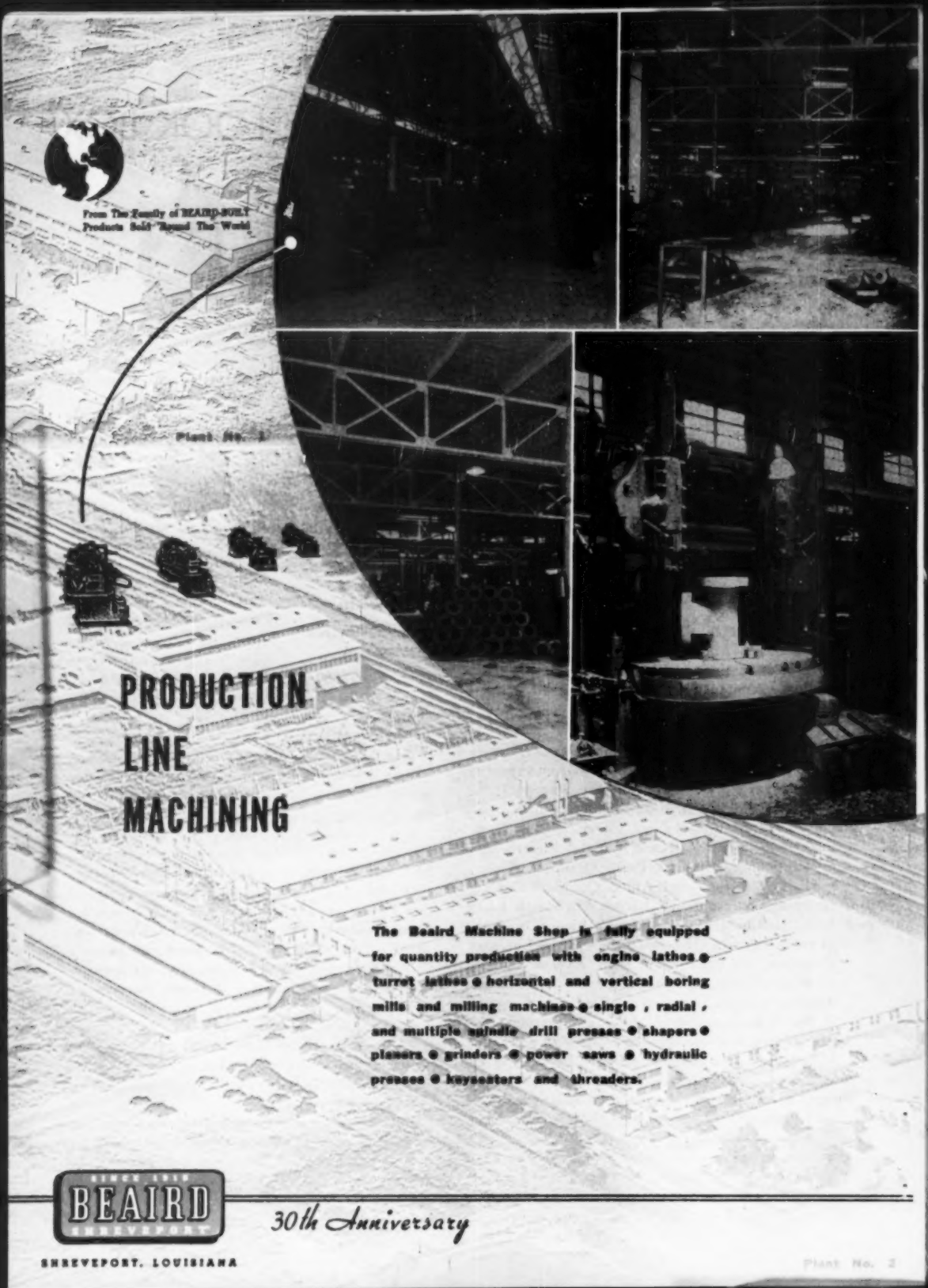
"THERE is nothing that communism can do for the world that capitalism isn't already doing better," says Warner & Swasey. "Communism promises security, and delivers work-or-starve and the dreadful security of a job for life in a slave labor camp, while capitalism promises security and delivers social security, wages enabling a man to save for his future, a standard of living higher in the worst times than communism gives at its best.

"Communism promises better living, and a communist has to work seven weeks to earn enough to buy a suit, while capitalism makes it possible for an American workman to buy a suit by working one week or less."

Finally, "coming to think of it," asks Warner-Swasey, "what else does communism even promise? But it delivers a great deal more—ballots with only one name on them; prison camps if you stay away from work; 'homes' of one room for entire families; government-dictated wages and prices so fixed that you will never rise above a bare and barren existence; riches for a few bureaucrats who keep themselves in power, poverty for everyone else; constant fear, frustration, hopelessness which only death can end.

"And yet there are people who call themselves Americans, working, scheming, plotting, day and night to force these 'blessings' of communism on you and your children."

Recently most of us saw in the newspapers or magazines pictures of new automobiles which are available to Russians. The terms didn't seem to be so very high, although the one designed to be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SINCE 1918
BEAIRD
SHREVEPORT
30th Anniversary
SHREVEPORT, LOUISIANA
Plant No. 2

within reach of the actual workman appeared to be pretty much of a junk heap. But the payoff was in the number of such cars manufactured per year —65,000—that's all, including both the high-priced model and the low-priced one!

Some Sense About Profits

WE HEAR much of high profits these days, and the oil industry comes in for considerable criticism because its profits have been substantially more during the past two years than in comparable periods before.

When we hear wages referred to, we hear a lot about how little the dollar buys—well, the same thing applies to profits. It cost a whale of a lot more to find a new barrel of oil than it did eight years ago: a 10,000-barrel modern refinery costs 2½ times as much to build today as it did a few years ago.

In our own company, we recently decided to buy replacement for a piece of equipment. The price of the equipment in 1941 was $17,000, f.o.b factory. The present f.o.b. price was $45,000!

What some unions do not seem to understand is that when present equipment is worn out, corporations are going to have a deuce of a time buying replacements to stay in business unless they make a reasonable profit in wearing out the old equipment.

Another thing about higher profits: Total sales have increased tremendously—far ahead of any figure with which we were familiar a few years ago. Yet despite greater total profits, the profit per thousand dollars worth of goods delivered is considerably less than it was a few years ago.

Our population is growing, more mouths to be fed, more jobs necessary to feed them. Where, in the name of common sense, will come the money for necessary expansion if profits are not enough to pay for the new factories and machines, and in the case of the oil business, to drill new and deeper wells and to provide refineries to process the oil?

Sell Your Ferrous Scrap

IF STEEL mill capacities are to be maintained at present levels, it will be necessary to accelerate the domestic flow of heavy steel scrap. The steel industry itself is conducting a program to salvage all ferrous scrap possible from the general public. The Department of Commerce, however, has suggested that a larger campaign should be directed to selected industrial groups. Secretary of Commerce Charles Sawyer, in explaining the urgent need for ferrous scrap, stated, ". . . without an increased supply of scrap our domestic economy and our foreign aid requirements will not have the badly needed benefit of maximum iron and steel production. During 1947 the iron and steel industry consumed approximately two million tons more of purchased scrap than any previous year. Despite this, the mills could have produced an additional three million tons of ingots and the foundries could have produced an undetermined tonnage of castings if more scrap had been available."

Top management and personnel of process plants can and should render heavy assistance to this salvage program. Most plants have on hand at least some equipment which has been discarded and has only junk value. Often this old equipment is assembled in a stock yard and allowed to rust away through the years. The appearance of plants and their over-all efficiency can thus be improved by ferreting out *all* worn-out or obsolete process equipment, piping, fittings, old machines now discarded, and so on—all sorts and kinds of ferrous scrap—which can be turned in through local salvage dealers for payment at existing rates. These same dealers can supply information on types, grades, sizes, and prices.

Send your scrap back to the mills! Help a national program of vital importance to our industry, and clean up your plant!

"Littles" Outstrip Oil Industry "Bigs"

THE "little fellows" in the oil industry are growing faster than the big ones, according to Dr. Joseph E. Pogue, vice president of The Chase National Bank.

A comparison of the net worth of 30 leading oil companies, made by the Petroleum Department of The Chase National Bank, shows that 13 companies, with net worth of less than $100 million each, increased their net worth on the average by about 63 percent in the seven years from December 31, 1940, to December 31, 1947. Many smaller companies increased their net worth even more.

The eleven companies of intermediate size, with net worth ranging from $100 million to $500 million grew slightly less than 46 percent over the same period. The six largest of the 30 companies, with net worth of more than a half billion dollars each, grew only 44 percent.

The smaller companies in the group also had higher percentage earnings, the comparison showed.

Fast exit for Coke

THERE'S POWER, AND DRIVE, and trouble-defying stamina in this hard-hitting team. Take that new Lagonda swing frame head alone — you get extra long cutting surface, extra wide swing in the arms, and extra long life too, because of the new Lagonda design of cutter pin which doesn't depend on screw threads to hold the cutters in place.

Now put behind that cutter head the extra power of the easy-spinning, high-speed, ball-bearing Lagonda 1100 Series motor, and you can see why those cutter arms swing out hard against the coke, and make the cutters bite deep.

They make a powerful team, those two. Try them on a really tough job, or when you want to make real time on a cleanout. Your nearest Lagonda office will arrange it.

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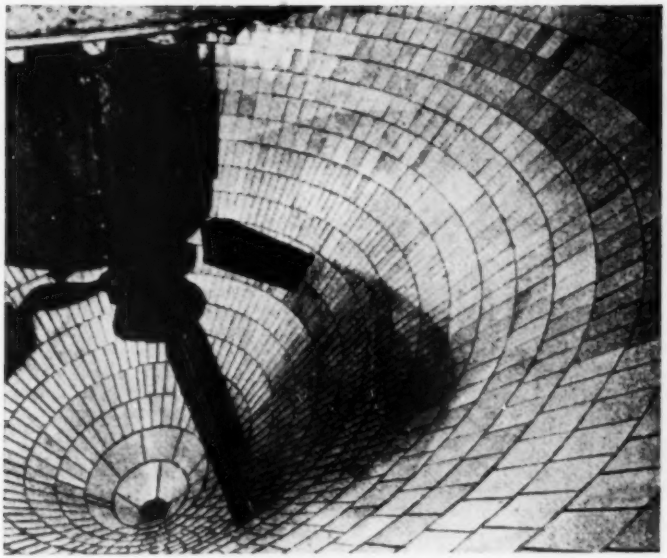


FIGURE 1
Acid-Proof Cone Bottom Tank Lining.

Corrosion-Resistant Masonry Construction

E. E. LUDWIG
Sectional Chemical Engineer, Texas Division
The Dow Chemical Company, Freeport, Texas

THE chemical and petroleum industries have many processes requiring corrosion protection for large and expensive equipment. Numerous methods, schemes, and ideas have been and are being used to give the required protection. This protection may be for steel-shelled vessels, alloy-shelled vessels, wooden vessels, concrete vessels, or even vessels or equipment constructed entirely of corrosion resistant materials.

For most conditions the required protection may be provided in the completed form as linings, walls, or floor areas by the use of:

A) Special bricks.
B) Special cement mortars or plasters.
C) Special membranes.
  1) Metallic.
  2) Paint.
  3) Plastic.
D) Combinations of A, B, and/or C.

This protection may be required for use in the presence of pure products or chemical or petroleum mixtures of acid, alkali, organic, or inorganic materials.

The primary consideration of this discussion will be the protection of process equipment and related plant areas using masonry construction, and will be centered around the special considerations for good serviceable construction.

Corrosion resistant masonry construction requires a complete and thorough understanding of the nature of the bricks and mortars being used in addition to the knowledge required for good brick construction work. Corrosion resistant brick and tile work is a distinct branch in the field of masonry construction and requires more than just the "know-how" of general mosonry construction. The brick masons working in corrosion resistant brick work must be specialists in the work and should have a real interest and pride in producing a flawless and first class job. In general, this type of work will proceed slower than ordinary brick masonry construction and it is to the advantage of the job not to rush the work to the point that quality is sacrificed for quantity or speed.

Specialization Factors

Several of the factors which contribute to the specialization required in chemical process masonry construction may be itemized as follows:

1) Special natures of the chemical and petroleum products being processed or stored in the equipment.
2) Special shapes and sizes of the vessels, equipment, and tanks being used in the process.
3) Special textures and shapes of the brick or tile required for the linings.
4) Special characteristics of the cements employed in the construction. Often more than one type of cement is used in the same lining operation.

In order to erect a sound, stable, and corrosion-resistant brick lining or structure, a thorough knowledge and understanding of the working characteristics and corrosion-resistant qualities of the numerous types and tradenames of brick and cements is required. Without this understanding of what is required of a particular job, and what is required to construct a good masonry

***A PREREQUISITE** to utilization of corrosion-resistant masonry construction for process equipment is a thorough knowledge of the materials involved. In addition, since corrosion-resistant brick and tile work is a distinct branch in the field of masonry construction, more than an understanding of the general technique of good brick construction is required.*

Corrosion resistant masonry construction in the chemical process industry has reached a stage of extreme importance in view of the necessity for corrosion protection for large and expensive equipment. This article constitutes a comprehensive review of materials and techniques in use in the chemical process industry today.

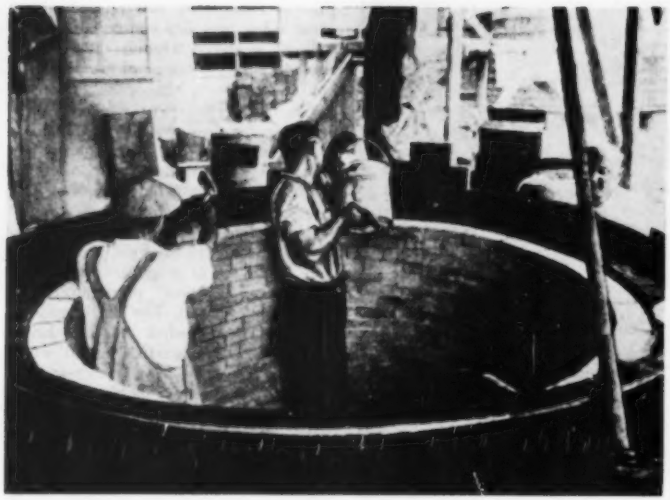


FIGURE 2
Acid-Proof Cylindrical Tank Lining.

job, the resultant work cannot be erected without the possibility of some seemingly minor defects causing a complete failure of the lining when placed in operation. Close supervision of each phase of the work is essential in order that any error in the erection may be quickly caught and repaired.

The terms "acid-proof" brick and "acid-proof" mortar are often used in the field as well as the office to refer to materials for a corrosion-resistant masonry job, regardless of the exact acid, alkali or other nature of the products to be processed in the finished vessel or area.

Brick

A) *Acid-Proof Brick* — Acid-proof brick are manufactured by several reliable concerns; however, it is often well to test several brick to determine the best for any given special job. For the usual acid service, most acid-proof brick will give satisfactory service. The brick should be acid resistant, dense, vitreous, unglazed, non-absorbent, and free from included foreign materials.

For certain conditions and to insure tight bonded joints, the bricks may be scored. A good acid-proof brick must be made with specially selected clays, and the formations of soluble silicates and alkalies should be held to a minimum. The brick should be uniform in size, highly refractory, of high mechanical strength and low coefficient of expansion.

B) *Alkali-proof brick* — The usual brick used for acid-proof service prove satisfactory for mild alkali solutions, and often, for strong alkali solutions. For conditions beyond the recommendations of the manufacturer, the brick should be placed under actual test conditions to determine suitability.

C) *Organic-proof brick*—For many conditions of corrosive organic materials, the standard acid-proof brick will function quite satisfactorily. To insure proper life of service, tests should be conducted under actual conditions.

D) *Special brick*—Brick of carbon, graphite or other special materials, are available to handle conditions beyond the range of the brick noted above. These special brick will usually handle strong alkali and hydrofluoric acid.

Acid-Proof Cements

A) *Silicate Cements*—Most of the silicate acid-proof cements employ a "powder" and sodium silicate solution of approximately 38° Be. The powder and solution are stored in separate containers and then mixed in small batches according to manufacturer's directions. This type of cement usually begins to set in 20 to 30 minutes after mixing and completely hardens in three to four days. Most silicate acid-proof cements are resistant to all inorganic acids except hydrofluoric acid; most organic acids; most solutions of acid and neutral salts, except fluorides; most organic solvents, alcohols, oils, and the like; steam; and water. They are usually not resistant to alkalis, alkali salt solutions, hydrofluoric acid, fluoride salt solutions, and some special organic chemicals. For specific resistance information regarding a particular service, the manufacturer and manufacturer's literature should be consulted. This type of cement is usually somewhat porous and not completely liquid tight.

(This and all other photos in this article courtesy of Atlas Mineral Products Company)

FIGURE 3
Acid-Proof Floor.

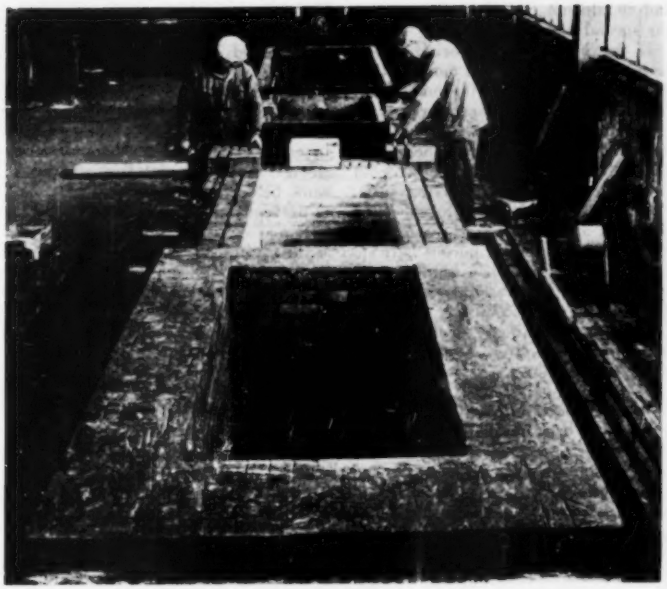


FIGURE 4
Carbon Brick Acid-Proof Lining for Concrete Tank.

B) *Resin Cements*—Most resin acid-proof mortars are prepared by mixing a resin cement powder and a resin solution according to manufacturer's directions.

Various types and bases of resin cements are available. The resin base may differ between manufacturer's products and thus impart different special resistant characteristics to the respective cements. There is much more selection as to trade-name and resistance characteristics in the resin base cements than in silicate cements. These cements may be just resin-solution combinations, or they may contain added materials such as carbon, graphite, stone pellets, and the like.

This type of cement is usually liquid tight, non-porous, and possesses higher adhesive, tensile, and compressive strengths than the silicate cements. The setting time and service temperature are generally less than for the silicate cements.

These resin cements are usually resistant to all acids, except high concentrations of highly oxidizing acids such as nitric and chromic. They are also resistant to all alkalis, fats and most solvents; however, manufacturer's recommendations and actual tests should be resorted to in selecting the proper cement for a desired service, as the resistance characteristics vary with the different makes.

General Precautions

It is possible to generalize to some extent regarding the rules and special considerations which should be respected when performing most acid-proof brick and tile masonry work. It should also be recognized that the list given below does not begin to cover all of the fine points which develop during the course of acid-proof masonry construction.

1) The brick *must* be clean and dry.

2) The brick should have a netural or slighty acid surface in order to insure the best bond with most types of acid-proof cements; however, some cases indicate that an alkaline surfaced brick appears to give satisfactory bonding results.

3) The brick must not have glazed surfaces, although a few slightly fused points may give satisfactory bonds between mortar and brick.

4) The brick surfaces should be "buttered" with the mortar rather than applying mortar directly to the vessel or floor surface being covered.

5) The brick must not be frozen.

6) The vessel or equipment to be protected should be tested for leaks before masonry work is started.

Surface Preparation

In general, for most acid proof cements the surfaces, whether floor or wall, should be neutral. Any surface which is alkaline should be given a wash with 5 to 10 percent hydrochloric acid, then washed with clear water, and finally dried. The surfaces may be tested by using some color indicator such as "Brom Thymol blue" and noting the characteristic color changes. It is essential that the surface be dry before any brick work is started.

Smooth or slick brick must be roughened by sandblasting, by hydrofluoric acid wash or similar treatment as may be applicable for the material.

Steel surfaces should be clean, grease free, dry and primed with special steel primer as manufactured for the purpose.

Concrete, brick and wood surfaces and vessels usually require an impervious membrane protection between the surface and the acid-proof brick lining. This protection may be concrete paint, asphalt, or some special membrane as mentioned above. Wherever possible, it is essential that this membrane be continuous and bonded to the surface being protected.

Treatment After Completion

For certain silicate cements and some special cements, it is recommended that after the mortar has dried, the entire exposed mortar be given an acid wash. This acid is usually 5 to 10 percent hydrochloric, and is allowed to soak into the joints before washing with clear water. Where possible and practical, the vessel or equipment should be filled with the acid and allowed to soak from 10 to 24 hours. This treatment tends to "set" the mortar and remove the alkaline film which is usually present on the surface. If the treatment is not used, water, very dilute acids, or concentrated acids coming in contact with the joints may cause failure of the mortar.

Mortar Preparation

For most of the available corrosion resistant cements, it is usually desirable not to mix large batches of mortar, due to the short setting and hardening time. Although it requires more work and tends to slow the brick laying, the mixing of small batches is rewarded in good adhesion and bonding of mortar to brick and brick to brick.

Most manufacturer's directions call for the cement "powder" to be added to the "solution" bit-by-bit and with continuous stirring until mixture is a smooth workable mortar. Lumps and entrapped air are eliminated by proper stirring and mixing and where practical, mechanical mixers should be used. The proportions required for the various mortars should be obtained from the manufacturer in addition to

setting time—temperature information. Experience in working the materials aids greatly in the proper mixing. Most mortars are greatly affected by temperature; thus it is important that this information be available for the particular cement being used, since similar information for some other brand of cement should not be relied upon to give good results. In general, the warmer the temperature above a reference temperature of 85° F., the greater is the tendency of the mortar to set; however, with temperatures less than approximately 50° F., the mortar should be warmed to keep it at not less than 50° F. Most manufacturers recommend that the mortars be kept below 120° . In order to have a reasonable working time with the mortar, it should be kept at about 85° F., and if necessary, the container may be immersed in cool water. Exact details should be obtained from the manufacturer. For most general work, the mortar should not be applied to surfaces exceeding 100° F.

The mortar joints between brick should be 1/16 to ⅛ inch in width, and should not exceed ⅛ inch unless for special circumstances.

If the joints between brick are to be pointed with a special mortar other than that which forms the main bond for the joints, it is necessary to prepare clean and square cut joints of approximately ¼ inch wide by ½ inch deep. The pointing mortar is then forced firmly and uniformly into the joint. Pointing is usually employed when the brick are bonded with the less expensive and slightly porous silicate cement mortar and then pointed with some non-porous resin-type mortar. Thus, sometimes by pointing, a cheaper job may be obtained which has the non-porous quality so desirable in many applications.

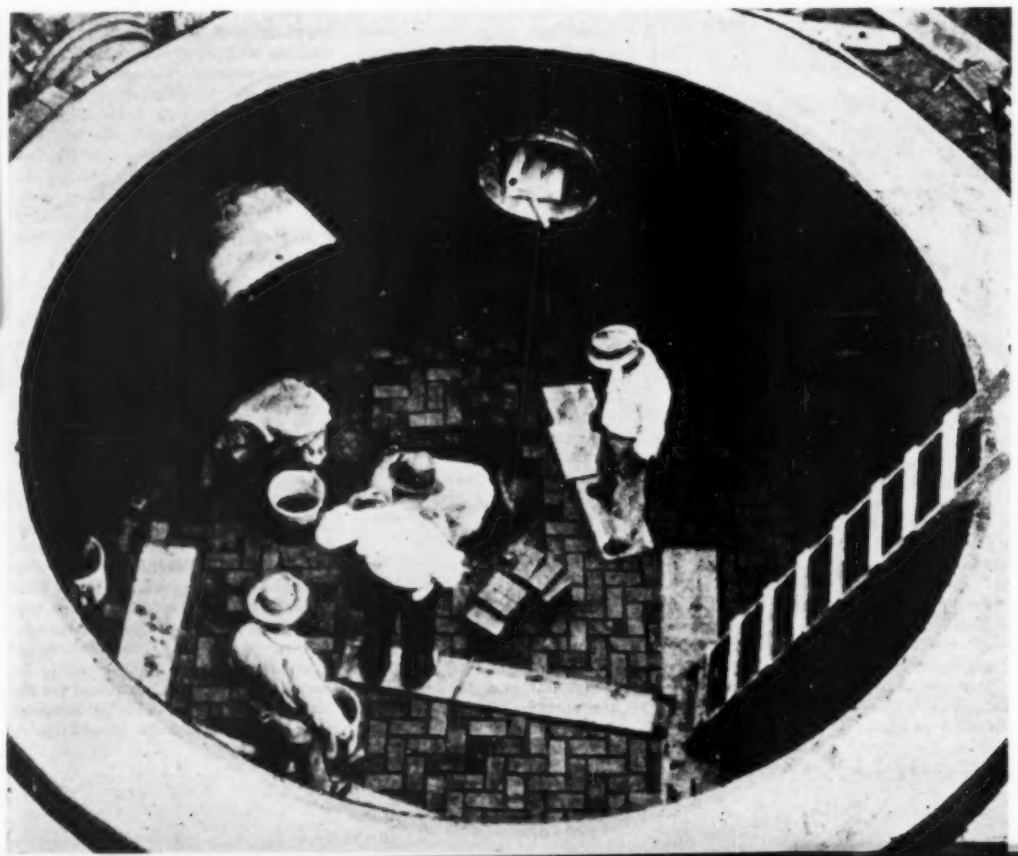
Nozzle and Other Opening Connections

Manway access, nozzle and other openings into equipment which is being lined in masonry construction should have special sleeve connections at these openings to allow a continuous corrosion resistant lining. These sleeves may be of brick, porcelain, glass, special resin, or other resisting material. The sleeves should be so designed, and the connection into the brick work so designed as to give a rigid and practical connection. They should be bonded in place with a non-porous mortar in order to prevent seepage and leakage around these connections. In order to prevent breakage of these sleeves, it is essential that the brick work be installed in a stable manner to prevent settling.

Manufacturer's Recommendations

Since the requirements of the numerous special chemical and petroleum products, with regard to corrosion resistant brick and mortar, are so varied, and also vary with temperature and concentration of the chemicals, it is recognized that the proper procedure is to contact and consult the various manufacturers of such material to obtain the recommendation for a desired service. Also, the individual manufacturer's mortar preparation procedures and conditions should be adhered to in order to insure a satisfactory masonry job. Guess-work and approximations are not sound bases for corrosion-resisting masonry construction.

FIGURE 5
Acid-Proof Flat Bottom Tank Lining.



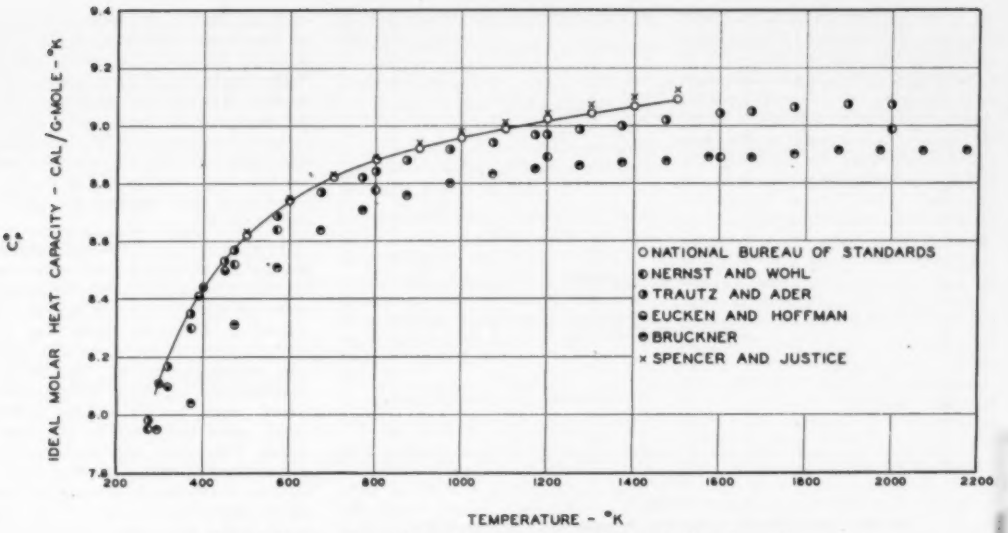


Figure 1. Literature Reported Heat Capacity of Gaseous Chlorine (at Zero Pressure).

THERMOCHEMISTRY For the Petroleum Industry

I. INTRODUCTION

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***THE AUTHOR** in this paper, which is the first of several which will appear at early intervals in Petroleum Refiner, seeks to put in useful form basic thermodynamic data, needed by "every technical man who has had occasion to make thermodynamic calculations to any appreciable extent." Problem solutions have varied in the past according to the sources of basic physical data and the obvious question always arises as to which are the most reliable.*

Thus this effort to collect all available heat capacity and enthalpy data on important gases and vapors, to evaluate them critically, to make a selection of the most reliable and to present them in the most readily useable forms.

THE organization of information in technical periodicals is by its nature haphazard. Most scientific journals are reluctant to publish review articles. The result is that the assimilation in useable form of valuable scientific and technical data trails in poor fashion the accumulation of such knowledge. Fortunately, this is not the case with all knowledge. Text-books and monographs on basic principles and fields of knowledge are constantly being revised and brought up to date. But the majority of scientific and technical data remains in the multitudinous journals — unorganized, barely catalogued, and available only after considerable effort.

This situation has long been recognized and is being remedied in slow, tortuous processes. Familiar notable examples that are of interest here are the *American Petroleum Institute Project 44*, the *National Bureau of Standards Tables of Selected Values of Chemical Thermodynamic Properties*, the *International Critical Tables*, (now woefully out of date), the series of monographs by Egloff on *Physical Constants of Hydrocarbons*, Bichowsky and Rossini's *Thermochemistry of Chemical Substances*, and others.

For several years the author has been teaching a course in thermodynamics. There certainly are sufficient textbooks available, for since 1921 there have appeared at regular intervals additional texts bringing the subject as closely up to date as possible. But the basic thermodynamic data were in no such useful form. This was painfully evident when certain class problems were assigned. The problem solutions would vary according to the sources of basic physical data. A simple glance at the literature is not sufficient to determine which are the most reliable data. Moreover, for direct solutions of many thermodynamic problems, it is almost mandatory for the heat capacity data to be in the form of an equation readily integrated and differentiated.

It is obvious that this is not a problem that is met with by the college student only. Every technical man who has had occasion to make thermodynamic calculations to any appreciable extent undoubtedly has been confronted with the same exasperating situation. That is the reason this work was undertaken.

The purpose of this work, then, is:

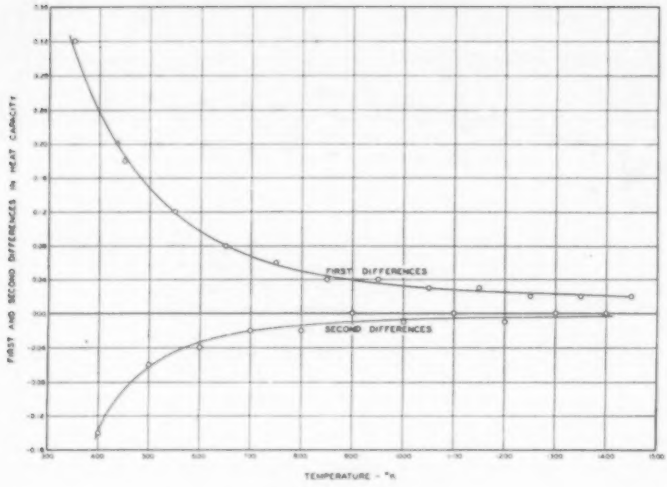

FIGURE 2

First and second difference curves show the regularity of the data selected.

a) to collect all the available heat capacity and enthalpy data on industrially and technically important gases and vapors.

b) To evaluate critically all these data.

c) To make a selection of the most reliable or "best" data for each gas or vapor.

d) To present these data in the most readily usable forms.

e) To present for each gas or vapor accurate heat capacity equations that may be easily differentiated and integrated.

f) To tabulate at 25° C., values for the standard heats of formation and combustion, and free energies of formation.

g) To make all this information available in one series of articles.

Selection of Heat Capacity Data

For each gas or vapor, a complete search through the literature was made for heat capacity and enthalpy data. Each source was carefully considered. When all the data had been collected, they were compared, analyzed, and a selection was made of what was considered the most reliable information. In only a few cases were any additional calculations of heat capacity made. After the selection of the most reliable data had been made, first and second difference curves of the data were constructed. If the data showed larger irregularities than the precision of the data warranted, adjustments were made until the second difference curve was smooth, or until the irregularities agreed with the assumed precision of the data. It was realized that this smoothing process did not improve the *accuracy* of the data, but the adjustments were of such magnitude that they did not seriously affect the accuracy. These "adjusted" data then, although probably no more accurate, were more self-consistent than the original data, i.e., the heat capacity-temperature variations were more regular.

The problem in the selection of the most reliable information is illustrated by considering chlorine. Available in the literature are six separate sets of data for the heat capacity of chlorine, all published since 1929, and all showing decided differences. The original data were not in all cases reported as $C°_p$, the ideal heat capacity at constant zero pressure so that data reported on any other basis had to be corrected to $C°_p$ by appropriate equations.

The calorimetric data of Eucken and Hoffman in 1929[9] are over such a short range of temperature as to be of little use. Nernst and Wohl[8] also published in 1929 a set of data which was the first to cover an extended range. A close examination of these data, however, show them to be erratic. Then in 1934 appeared the data of Spencer and Justice[13] in America and the data of Trautz and Ader[14] in Germany. Both of these latter sets are calculated over extended temperature ranges, from spectroscopic measurements but they show decided differences. The data of Bruckner[1] in 1935 show several unexplained irregularities; also Bruckner was not specific in detailing his method of calculation. The latest published data are those of the National Bureau of Standards[10] which appeared June 30, 1948. These were calculated[11] using the molecular constants of Spencer and Justice, with partition functions computed from these constants by the relations of Mayer and Mayer.[7] These data were selected for chlorine and used in these reports. All of the various sets of data reported are plotted in Figure 1.

In order to be sure that the National Bureau of Standards data were consistent, first and second differences were calculated and are plotted in Figure 2. This plot shows that the irregularities in the data are within the reported precision. By suitable mathematical formulas, these selected "best" data, usually on the Kelvin scale, were converted to the Centigrade, Fahrenheit and Rankine temperature scales. Then the heat capacities were tabulated at integral hundred degree increments on all four temperature scales from the ice-point to the maximum reported or useful temperature. In addition to the integral hundred degree values, the data were recorded at 0, 18 and 25° C., 273, 291 and 298° K., 32, 60 and 77° F., and 492, 520 and 537° R.

No difficulty is encountered with units for heat capacity. The numerical values are identical on all scales. Thus:

$$\frac{\text{calories}}{\text{g-mole} \cdot °\text{C.}} = \frac{\text{Pcu.}}{\text{lb-mole} \cdot °\text{C.}} = \frac{\text{Btu.}}{\text{lb-mole} \cdot °\text{F.}}$$

The gram-mole and pound-mole have been selected as the mass basis for all compounds. This usually is the formula-weight and the chemical formula will be written to correspond to the molecular species, as S_2 represents the sulfur molecule in the vapor state at high temperature. The pound-centigrade unit, Pcu., will be used frequently because of the simplicity with which it changes thermal data from the basis of metric units, or grammoles, to English units, or poundmoles. It may be considered the amount of heat required to raise the temperature of a pound of water one degree centigrade (at 17° C.). The following relationships exist among the units for the *amounts* of heat:

$$\frac{\text{calories}}{\text{g-mole}} = \frac{\text{Pcu.}}{\text{lb-mole}} = 1.8 \frac{\text{Btu.}}{\text{lb-mole}}$$

The relationship between th Pcu. and Btu. is that of the Centigrade and Fahrenheit thermometer scales.

Enthalpy and Meat Heat Capacity

The selected heat capacity values were then plotted on large scale coordinate paper and the enthalpies, on all four temperature scales were calcu-

lated by accurate graphical and mathematical methods. The ice-point, 0°C. = 32° F., was used as the enthalpy base temperature, i.e., the gas or vapor was arbitrarily assumed to have an enthalpy of zero at the ice-point. The enthalpy values were recorded at the same temperatures as were the heat capacities.

From the enthalpy values, mean heat capacities over the range from 0°C. to t° were calculated for the Centigrade and Fahrenheit scales. The mean heat capacity is defined and was calculated by the equation

$$C^\circ_{p_m} = H^\circ/(t - t_o) \quad (1)$$

where

$C^\circ_{p_m}$ = ideal mean heat capacity above t_o

H° = ideal enthalpy above t_o (0° C. = 32° F.) at t degrees,

t = temperature of gas, °C. or °F.

t_o = reference or base temperature for both enthalpy and mean heat capacity = 0° C. = 32° F.

The relationships among heat capacity, enthalpy and mean heat capacity are apparent from Figures 3 and 4.

The area under the heat capacity curve from the ice-point (0°C.=32°F.) to a definite temperature t_1 is the relative enthalpy. If this area is divided by the abscissa, the quotient is the average ordinate, in this case, the average or mean heat capacity over the range 0° to t_1°. This process can be repeated to secure a value of $C^\circ_{p_m}$ at a number of temperatures, $t_1, t_2, t_3 \ldots t_n$. The relationship of $C^\circ_{p_m}$ to C°_p can be seen by plotting both in the same figure.

Although the mean heat capacity can be calculated over any temperature range, in these papers it will be considered only over the range from the ice point to t°. Hence it can be used to calculate the enthalpy at any temperature above t_o.

$$H^\circ_1 = C^\circ_{p_m}(t_1 - t_o) \quad (2)$$

$$= C^\circ_{p_{m_1}}(t_{c_1} - 0) \text{ in Centigrade units}$$

$$= C^\circ_{p_{m_1}}(t_{f_1} - 32) \text{ in Fahrenheit units}$$

For the enthalpy difference between two temperatures this gives:

$$H^\circ_2 - H^\circ_1 = C^\circ_{p_{m_2}} \cdot t_2 - C^\circ_{p_{m_1}} \cdot t_1 \quad (3)$$

Mean heat capacity values are frequently shown on curves or tabulated because they are smaller numbers than enthalpies, but they have the disadvantage that they must be multiplied by a temperature interval to give the desired enthalpy.

Heat Capacity Equations

It was desired to develop a mathematical equation from which the heat capacity can be calculated over a 1200°C. (2200°F.) temperature range. The equation selected must fit the data with an accuracy that will permit its use in engineering calculations, it must be easily differentiated and integrated, and it must not be unduly cumbersome. The following four types of equations are in common use.

$$C = a + bT + cT^2 \quad (4)$$

$$C = a + bT - cT^{-2} \quad (5)$$

$$C = a + bT + cT^{-1/2} \quad (6)$$

$$C = a + bT + cT^2 + dT^3 \quad (7)$$

Equation 4, although useful for short temperature interval interpolations, is not suitable for a 2200°-temperature interval. Its use over such a large temperature range almost always results in prohibitive errors. Equation 5, advocated by Maier and Kelly,[6] has been applied particularly to the high temperature heat capacity of solids where the curve flattens out at higher temperatures. Kelly has used this equation in his series of Bureau of Mines bulletins. Equation 6 was advocated by Chipman and Fontana[2] for metallurgical substances and shown to fit better for certain substances than equation 5. For high temperature *extrapolation* they are the only equations listed above that are suitable. However, at lower temperatures they fit the data poorly. They are difficult to use and have the serious disadvantage that they cannot be used on the Centigrade or Fahrenheit temperature scales. Equation 7 has many advantages despite the fact that it has one more constant than Equations 4 to 6. It is easily differentiated and integrated. It is the only simple equation that will fit the heat capacity data of practically all gases and vapors with a reasonable accuracy. In a few cases equations 5 and 6 fit the data somewhat better than equation 7. For general utility, equation 7 is undoubtedly the best choice and it has been selected for this work. Out of some 75 to 100 compounds, there were only about six cases in which the best equation of type 7 showed a maximum error of more than one percent. It should be emphasized that the equations reported in this work are strictly empirical and apply only over the temperature range indicated. Anyone who has had any exposure to statistical mechanics realizes that the fundamental equations of heat capacity are far too complex to be considered for engineering calculations.

Once the form of the equation to be used has been selected an interesting problem is the calculation of the empirical constants so that the equation will best represent the data. The method of least squares is extensively used in scientific work. By this method, the equation derived is the *one* equation (of that form) for which the sum of the squares of the deviations is a minimum. The reason this method is

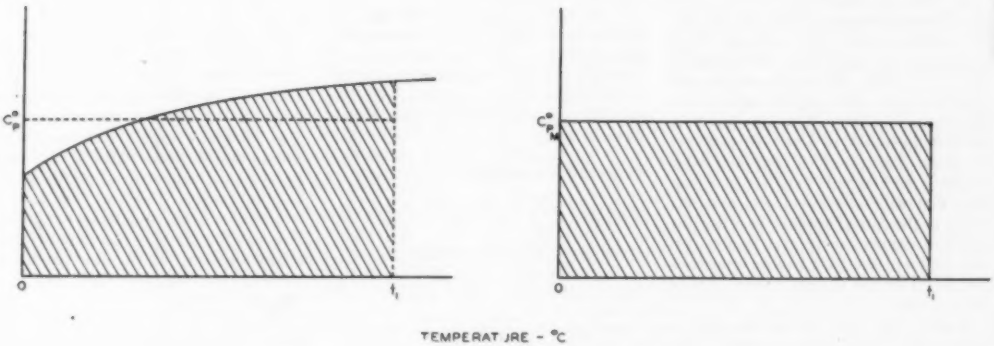

FIGURE 3
The mean heat capacity at t° is the average ordinate at this temperature.

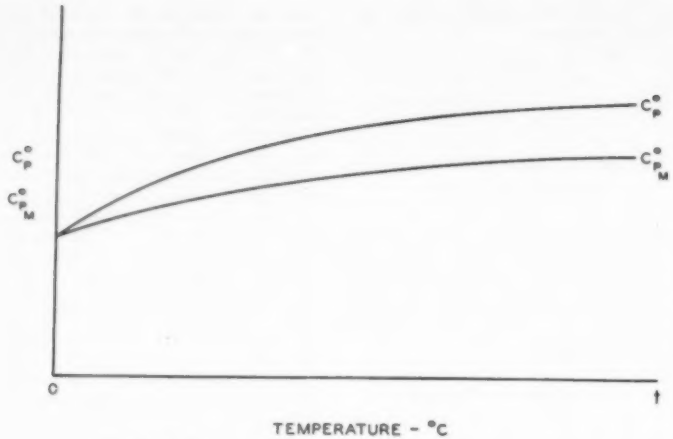

FIGURE 4
Heat capacity and mean heat capacity curves start from the same point at 0° C.

so extensively used is that the square of the error is a measure of its improbability. Deriving least square equations for heat capacities of gases is a long and laborious process. Nevertheless, such equations were derived for about 95 percent of the gases reported in this work. The results were unsatisfactory in most cases. Spencer[12] has recently published least squares equations for 117 gases using the data of API Research Project 44.[9]

It is to be noted that the error considered in the usual form of the least squares method is the deviation of the value calculated by the equation from the experimental value or smoothed curve which the equation is to represent. If the magnitude of the dependent variable (heat capacity) does not change appreciably, the range of deviation and the range of percent deviation are of the same magnitude. But in some cases the heat capacity at 2200° F. is four times as great as at 32° F. Thus the same deviation at 2200° F. and 32° F. would be four times as great when expressed as percentage deviation at 32° as at 2200°. Moreover, the heat capacity usually rises rapidly at low temperatures and then begins to level off so that the range of low heat capacity is short. The result is that the least squares method will produce an equation that will have its largest absolute error at the low temperatures—just the place it causes the largest percent error. Some of the least square equations produced errors in this range of 8 to 10 percent.

Unlike the pure scientist who is often concerned with absolute error, the technical man is usually interested in percentage error. Therefore, in this work the least square equations were considered unsatisfactory and are not reported. The method used here consisted of arbitrarily selecting four points on the heat capacity curve and deriving the equation that passed through those points. The heat capacities were then calculated by this equation on integral hundred degree points over the entire temperature range. The percentage deviation—temperature curve was then drawn. From this it could be noted how the equation could be further improved. This process was repeated until it was evident that the optimum balance had been obtained between maximum percentage deviation and average percentage deviation. This "best" equation, so derived, usually compared very favorably with the least squares equation in average percentage deviation and did not have the prohibitive error at the lower temperatures.

A typical comparison of the two equations is obtained by considering ethane. The ideal heat capacity of ethane at 0° C. is 11.856 and at 1200° C. is 34.70 cal./g-mole • °C. For this compound the following equations were derived:

Least squares equation:

$$C^\circ_p = 11.711 + 3.411 \times 10^{-2}\ (t) - 1.525 \times 10^{-5}\ (t^2) + 2.287 \times 10^{-9}\ (t^3) \quad (8)$$

Empirically derived equation:

$$C^\circ_p = 11.800 + 3.326 \times 10^{-2}\ (t) - 1.390 \times 10^{-5}\ (t^2) + 1.740 \times 10^{-9}\ (t^3) \quad (9)$$

where:

C°_p = ideal heat capacity in cal./g-mole • °C.,

t = temperature in degrees Centigrade

The least squares equation has an average deviation of 0.26 percent but a maximum of 1.22 percent. The empirically derived equation has an average deviation of 0.30 percent but a maximum of only 0.87 percent.

The Use of Heat Capacity Equations

An obvious advantage of accurate heat capacity equations is their brevity. In one simple equation is contained usually within one-half of a percent, the heat capacity of a compound over a large temperature interval. But the greatest use of such equations is in the thermodynamic computations. The two most important equations involved are the equations relating the heat of a reaction with the temperature and the equation relating the free energy of a reaction with the temtemperature.[4] The two equations are:

$$\Delta H_R = \Delta H_o + \Delta a T + \frac{\Delta b}{2} T^2 + \frac{\Delta c}{3} T^3 + \frac{\Delta d}{4} T^4 \quad (10)$$

$$\Delta G^\circ = \Delta H_o - \Delta a T \cdot \ln T - \frac{\Delta b}{2} T^2 - \frac{\Delta c}{6} T^3 - \frac{\Delta d}{12} T^4 + I_G T, \quad (11)$$

where:

ΔH_R = heat of reaction at temperature T,

ΔH_o = integration constant,

ΔG° = standard free energy change of the reaction at temperature T,

I_G = integration constant.

Δa, Δb, Δc and Δd are defined by writing the equation for the reaction as follows:

$$n_A A + n_B B = n_R R + n_S S, \quad (12)$$

where: n_A, n_B, n_R and n_S = number of moles of components A, B, R and S, respectively.

The heat capacity equations reported in this work are of the form:

$$C^\circ_p = a + bT + cT^2 + dT^3$$

Then for the equations 10 and 11:

$\Delta a = n_R a_R + n_S a_S - n_A a_A - n_B a_B$

$\Delta b = n_R b_R + n_S b_S - n_A b_A - n_B b_B$

$\Delta c = n_R c_R + n_S c_S - n_A c_A - n_B c_B$

$\Delta d = n_R d_R + n_S d_S - n_A d_A - n_B d_B$

Thus, having the heat capacity equations of the components of the reaction, the free energy and the heat of reaction may be calculated at any temperature with only two additional pieces of information. These are the heat of reaction at some temperature and the free energy of the reaction at some temperature. These are needed to evaluate the constants, ΔH_o and I_G in equations 10 and 11.

The use of the heat capacity equations, the tabulated enthalpy values and the tabulated mean heat capacities may all three be illustrated by consid-

ering the very simple reaction

n-Butane ⇄ *iso*-Butane.

The heat of reaction ΔH_R, is — 1640 cal./g-mole at 25° C.[9] It is now desired to know the heat of reaction at 1000°C. The following data are taken from tabulations of data that will appear in the next installment of this series of articles.

Normal Butane

$C^\circ_p = 22.060 + 6.663 \times 10^{-2}\,(t) - 3.697 \times 10^{-5}\,(t^2) + 8.360 \times 10^{-9}\,(t^3)$

$C^\circ_{p_m}$ (at 25° C.) = 22.89 cal./g-mole • °C.

$C^\circ_{p_m}$ (at 1000°C.) = 45.16 cal./g-mole • °C.

H (at 25°C.) = 572.3 cal./g-mole

H (at 1000°C.) = 45,160 cal./g-mole

Iso-Butane

$C^\circ_p = 21.382 + 7.202 \times 10^{-2}\,(t) - 4.519 \times 10^{-5}\,(t^2) + 11.92 \times 10^{-9}\,(t^3)$

$C^\circ_{p_m}$ (at 25°C.) = 22.24 cal./g-mole • °C.

$C^\circ_{p_m}$ (at 1000°C.) = 45.33 cal./g-mole • °C.

H (at 25°C.) = 556.6 cal./g-mole

H (at 1000°C.) = 45,330 cal./g-mole

a) Solution by use of heat capacity equations:

$\Delta a = 21.382 - 22.060 = -0.678$

$\Delta b = (7.202 - 6.663)\,(10^{-2}) = +0.539 \times 10^{-2}$

$\Delta c = (-4.519 + 3.697)\,(10^{-5}) = -0.822 \times 10^{-5}$

$\Delta d = (11.92 - 8.360)\,(10^{-9}) = +3.56 \times 10^{-9}$

Substituting into Equation 10 at t = 25° C., $-1640 = \Delta H_o + (-0.678)\,(25) + (\tfrac{1}{2})\,(+0.539 \times 10^{-2})\,(25)^2 + (1/3)\,(-0.822 \times 10^{-5})\,(25)^3 + (\tfrac{1}{4})\,(+3.56 \times 10^{-9})\,(25)^4 = \Delta H_o - 16.95 + 1.68 - 0.04$ + neg. ∴ $\Delta H_o = -1625$ cal./g-mole

Equation 10 then becomes

$\Delta H_R = -1625 - 0.678 + 0.2695 \times 10^{-2}\,(t^2) - 0.274 \times 10^{-5}\,(t^3) + 0.89 \times 10^{-9}\,(t^4)$

Then at t = 1000° C.,

$\Delta H_R = -1625 - 678 + 2695 - 2740 + 890 = -1458$ cal./g-mole at 1000°C.

Since the heat of reaction at any temperature is equal to the heat of reaction at some known temperature plus the net change in enthalpy of the products and reactants, we may solve the problem by evaluating the *change* in the heat of reaction. The change in the heat of reaction is equal to

$$\int_1^2 \Delta C_p dt = \left[C_{p_{m_2}} \cdot t_2 - C_{p_{m_1}} \cdot t_1 \right]_{\text{products}} - \left[C_{p_{m_2}} \cdot t_2 - C_{p_{m_1}} \cdot t_1 \right]_{\text{reactants}} \quad (13)$$

$$= \left[H_{t_2} - H_{t_1} \right]_{\text{products}} - \left[H_{t_2} - H_{t_1} \right]_{\text{reactants}} \quad (14)$$

b) Solution using the tabulated mean heat capacity values:

$\int_{25}^{1000} \Delta C_p dt = (45.33)\,(1000) - (22.24)\,(25) - (45.16)\,(1000) - (22.89)\,(25) = +176$ cal./g-mole

∴ $\Delta H_R = -1640 + 176 = -1464$ cal./g-mole at 1000°C.

c) Solution using the tabulated enthalpy values:

$\int_{25}^{1000} \Delta C_p dt = (45{,}330 - 556.6) - (45{,}160 - 572.3) = +186$ cal./g-mole

∴ $\Delta H_R = -1640 + 186 = -1454$ cal./g-mole at 1000°C.

Comparison of results:

ΔH_R (by use of equations) = —1458 cal./g-mole

ΔH_R (by tabulated C_{p_m} values) = —1464 cal./g-mole

ΔH_R (by tabulated H values) = —1454 cal./g-mole

Equations similar to these can be formulated for the change in free energy with temperature, from which can be calculated the equilibrium concentrations of the reactants and products at any temperature.

Heat Capacity at Higher Pressures

The heat capacity and enthalpy data are for gases in their hypothetical ideal state of unity fugarity, or zero pressure. Because industrial processes operate at finite pressures the effect of pressure on heat capacity and enthalpy is of interest. The equation for heat capacity at zero pressure has already been combined with heats of formation or heats of combustion at one atmosphere pressure to calculate these energy quantities at temperature other than the standard, 25° C. Because the change in heat capacity or enthalpy with pressure is usually quite small it is permissible to do this. The magnitude of the effect can be calculated for any given gas by assuming an equation of state for the gas. If the Berthelot equation, equation 15, is assumed, the change in heat capacity and enthalpy with pressure can be calculated from equations 16 and 17.[15]

$$pV = RT\left[1 + \frac{9}{128}\frac{P_r}{T_r}\left(1 - \frac{6}{T_r^2}\right)\right] \quad (15)$$

$$C_p - C^\circ_p = \frac{324RP_r}{128T_r^3} \quad (16)$$

$$H_p - H_o = \frac{9RT_cP_r}{128}\left(1 - \frac{18}{T_r^2}\right) \quad (17)$$

In equations 15, 16 and 17, the reduced pressure, P_r, and reduced temperature, T_r, are calculated from the actual pressure and temperature, by dividing by the critical pressure, P_c, and temperature, T_c, for the gas.

The Berthelot equation does not represent well the behavior of the actual gas at pressures above a few atmospheres. Thus for engineering purposes the compressibility factor, Z, of equation 18 can be used:

$$pV = Z\,NRT \quad (18)$$

Hougen and Watson[5] have developed a series of generalized charts that can be used for any gas for which values of the critical constants are known. The use of these equations is explained in their text.

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ACKNOWLEDGMENTS

This work was started in 1945 by the senior and graduate students in chemical engineering thermodynamics. Each student has surveyed completely the literature on one compound and prepared a detailed report covering his gas. These reports have furnished the background of information and data on which this series of articles is based. It is the writer's hope that the students' feeling of pride in professional accomplishment was sufficient recompense for the long hours spent on these reports. To each student acknowledgment is gratefully made for the assistance he has given this project.

The data presented in these reports were checked and recalculated by Ernest G. Long, first as University research assistant and then as Celanese Corporation Fellow in Chemical Engineering. His meticulous care in calculating the results reported has been essential to this project.

The excellent drawings presented in these articles have been prepared by Ray Tuggle.

READERS' COMMENTS

The writer will appreciate receiving the comments of the readers concerning the utility of this work. Since its aim is practicality, the engineer using these data should suggest additions that will save him time.

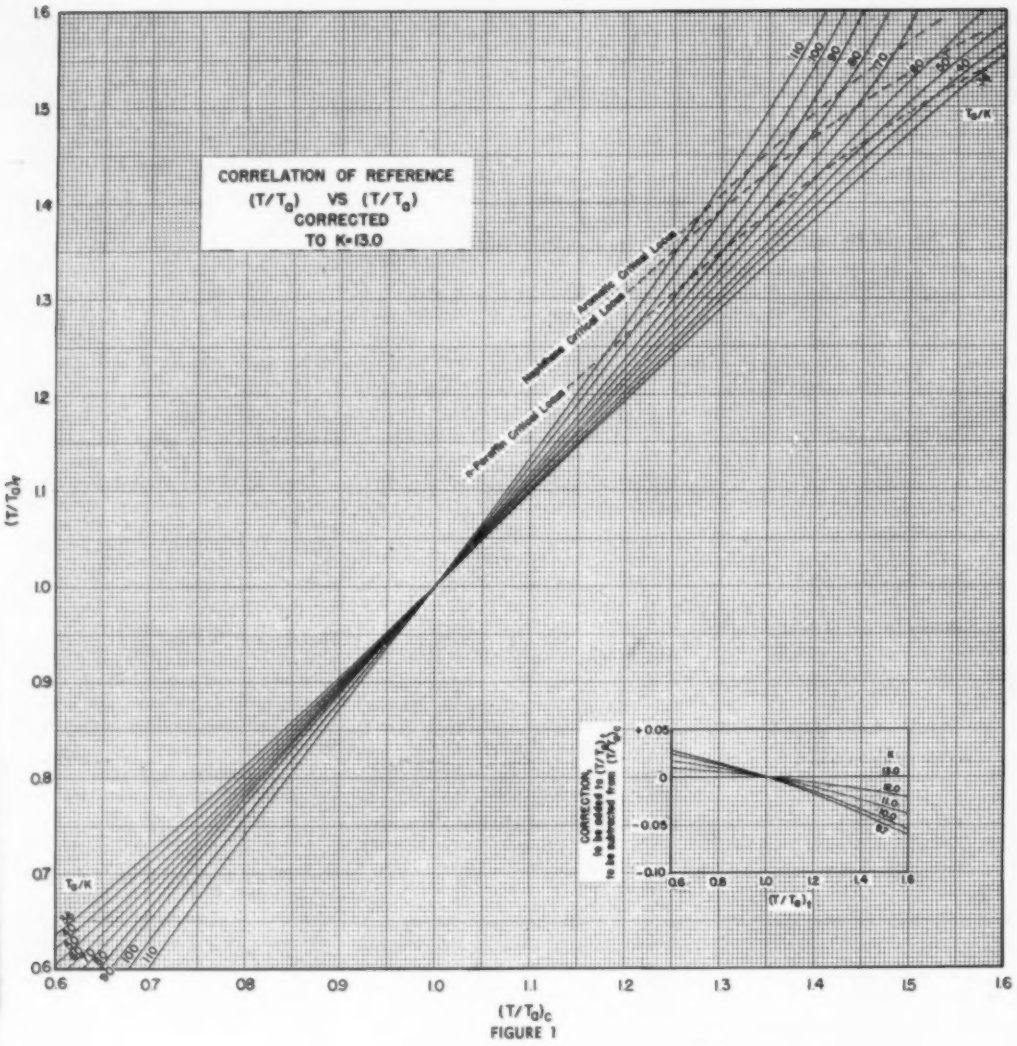

FIGURE 1

Pressure-Temperature Correlations For Petroleum Oils and Hydrocarbons

MATTHEW VAN WINKLE

Associate Professor of Chemical Engineering, University of Texas, Austin

VAPOR pressure-temperature charts have many practical uses for the engineer concerned with petroleum equipment design. Where pure compounds are being considered, vapor pressure charts indicate directly the pressure exerted by the hydrocarbon at any temperature, or the temperature at which the compound exerts a given pressure. In computations involving multicomponent hydrocarbon mixtures whose compositions are known, vapor pressure of the mixture (at lower pressures) may be computed from Raoult's Law at a given temperature or, conversely, the temperature may be computed for a given vapor pressure of the mixture. In the case of highly com-

plex hydrocarbon mixtures such as represented by petroleum oils, the vapor pressure charts afford a means of transposition of points on the various atmospheric pressure distillation curves to process pressures which may be higher or lower than atmospheric pressure. Also by means of the distillation data and vapor pressure charts it is possible to predict pressures corresponding to key or limiting process temperatures if certain proven empirical calculation procedures are followed.

Petroleum Distillation Curves

There are three principal types of atmospheric pressure distillation or vaporization curves which are used in petroleum design; true boiling point (TBP), Engler or ASTM, and equilibrium flash vaporization curves.

The TBP curve is a plot of volume percent distilled (usually) versus temperature of the vapor and is derived from a batch distillation involving a high degree of fractionation and a high reflux ratio. Because of the nature of the distillation, any point on the TBP curve represents the atmospheric boiling temperature of a pure hydrocarbon compound appearing at this percent distilled. Thus the TBP curve of a ten component mixture would consist of a series of ten plateaus, each appearing at the atmospheric boiling point of an individual component and whose length along the volume percent axis would correspond almost exactly to the volume percent represented by that component.

The Engler or ASTM distillation curve is a plot of the volume percent recovered versus temperature of the vapor. The data are derived from a batch, differential distillation involving very little fractionation and almost no reflux. Because of the method involved, the Engler type distillation data *as such* cannot be used in design computations.

The equilibrium flash vaporization curve is a plot of the volume percent vaporized versus the temperature of the vapor and liquid in equilibrium. The experimental data are derived from a continuous process wherein the vapor and liquid are maintained in intimate contact and there is no fractionation involved.

The TBP curves are determined on petroleum stocks for the purpose of evaluation of vaporization characteristics. The ASTM or Engler curves are determined for product specifications. The equilibrium flash vaporization curve is usually not determined experimentally because of the difficulty in operation and control of the equipment and the uncertainty as to the degree of equilibrium attained.

Physically, however, equilibrium flash vaporization is encountered in practically all situations in petroleum refining where vaporization and condensation is involved, e.g., vaporization in furnace tubes and heaters, transfer lines, on fractionation column plates, partial condensers, etc. For quantitative design purposes therefore, it is necessary to evaluate the flash vaporization curve of the oil or fraction as accurately as possible at the pressure at which the processing is to be conducted. This pressure is rarely atmospheric pressure and transposition of the flash curve to other than atmospheric pressure requires the use of vapor pressure-temperature charts.

A NEW VAPOR pressure-temperature correlation for petroleum oils and hydrocarbons presented here includes characterization factor as a variable and therefore modifies the vapor pressure - temperature relationship to account for the chemical nature of the oil fraction or hydrocarbon. Two accompanying charts eliminate the necessity for use of the conventional hydrocarbon vapor pressure charts where computations involving petroleum oil fractions are concerned.

The author also presents a plot relating atmospheric pressure true boiling distillation curve 50 percent temperature, 10-70 percent atmospheric pressure, true boiling, distillation curve slope, cubic average boiling temperature, API gravity, and UOP characterization factor, K. This plot gives a ready means of estimation of K from true boiling point distillation data and API gravity.

Calculations involving use of the correlations are included.

Correlation of Atmospheric Pressure Distillation Curves

Because of the difficulty of obtaining experimental equilibrium flash vaporization curves, design calculations are dependent in most instances on empirical correlations between the experimental TBP and Engler distillation data and equilibrium flash vaporization curves. Many correlations have been developed which establish the relationship between the 50 percent boiling points of ASTM, TBP, and flash vaporization curves. In addition, TBP distillation curve slope, ASTM curve slope and flash slopes (usually the 10 percent-70 percent slopes) have been related empirically. Nelson and Souders,[1] Nelson and Harvey,[2] Packie,[3] and Edmister[4] have published such correlations. Methods of correcting for curvature have been presented by Nelson,[1] Packie,[3] and Edmister.[4]

Probably the most widely adopted correlation has been that of Nelson and Souders because of its simplicity and general applicability. Recently Nelson and Harvey[2] modified the original correlation and included slope of the distillation curve as a variable.

Transposition of Distillation Curves to Other Than Atmospheric Pressure

The correlations noted above enable the determination of atmospheric ASTM and flash vaporization curves from TBP distillation data or of atmospheric TBP and flash curves from ASTM distillation data.

Because petroleum processing rarely is conducted at exactly atmospheric pressure, it is necessary to transpose the atmospheric flash vaporization curve to the pressure under consideration. The method extensively used in design calculations is to transpose a suitable temperature point on the flash curve to the new pressure, evaluate the slope of the flash curve at the new pressure, and compute the other temperature-percent points.

Formerly it was assumed (because of a lack of pressure flash vaporization data) that the slope of the flash curve was the same at any pressure as it was at atmospheric. More recently Griswold and Klecka[5] published a correlation relating the slope of the flash curve at any pressure to the flash slope at atmospheric pressure with reduced pressure or reduced temperature. This correlation indicates the slope of the flash vaporization curve decreases as the pressure increases above atmospheric pressure and reaches the value of zero at the critical pressure. It also tends to indicate the slope of the flash curve to be the same at sub-atmospheric pressures as the atmospheric pressure slope.

It is common practice to transpose to the new pressure either the atmospheric pressure 50 percent TBP temperature or the temperature representing the point of intersection of the atmospheric TBP curve and the atmospheric flash curve. This is done by means of the *n*-paraffin vapor pressure chart. While the latter procedure is the more theoretically correct, since only the intersection of the flash and TBP curve represents a compound having that atmospheric boiling point, it has been observed that transposition of the 50 percent flash temperature gives bet-

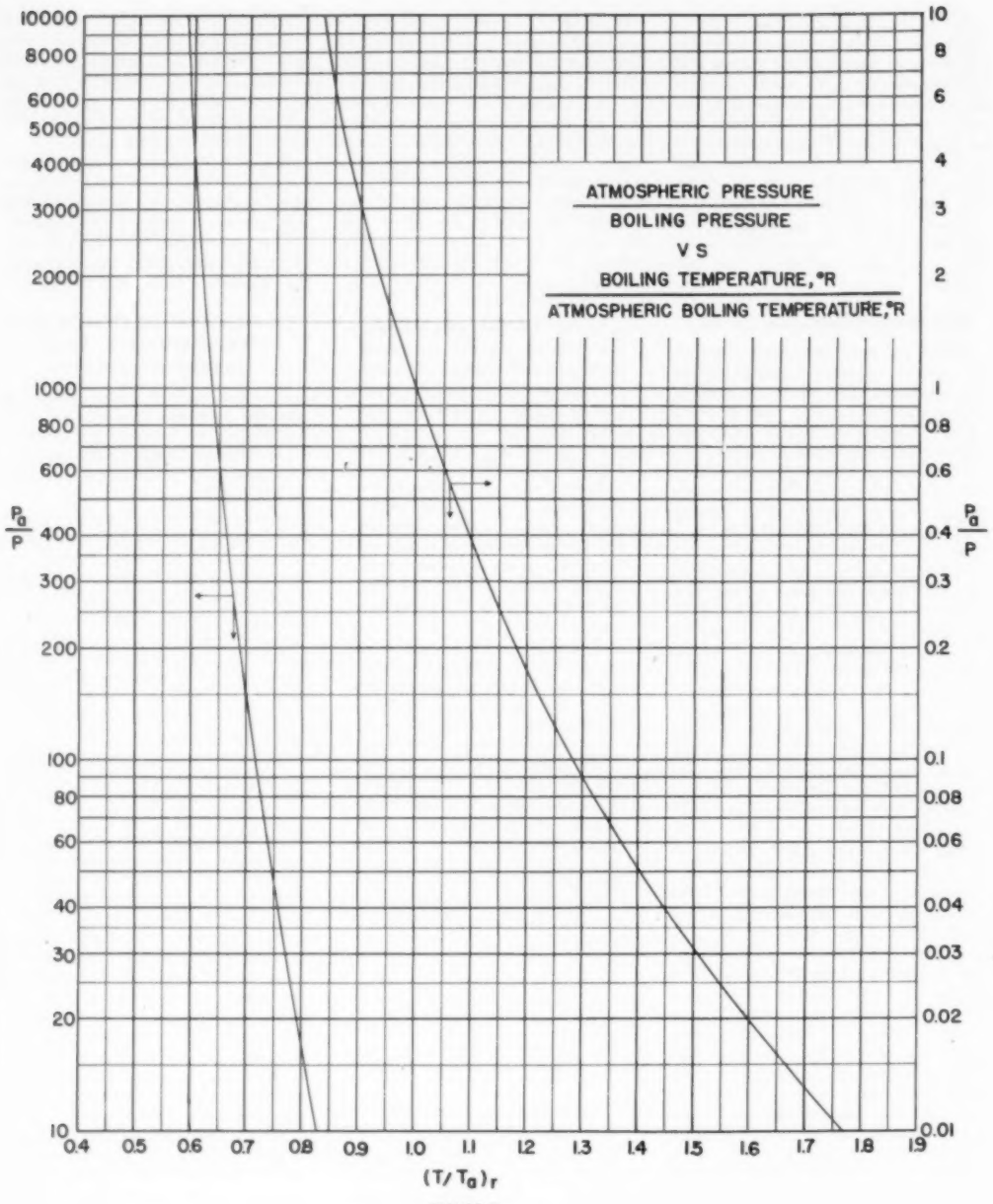

FIGURE 2

ter agreement between calculated and observed bubble and dew points. Closer agreement between calculated and observed data using the 50 percent flash temperature transposition probably indicates erroneous slope adjustment for pressure or erroneous temperature transposition, or both.

Proposed Method of Temperature Transposition

It was noted above that the vapor pressure charts for the *n*-paraffin hydrocarbons are used for transposition of a temperature on the flash curve to the new pressure. Vapor pressure charts available are those of Cox, Smith,[6] Brown,[7] Brown and Coats,[8] and Brown, et al.[9] The recommended procedure is to locate the atmospheric temperature to be transposed on the atmospheric pressure line, follow a line parallel to the nearest *n*-paraffin hydrocarbon line to the desired pressure and read the temperature at that point.

This procedure assumes that regardless of the chemical character of the hydrocarbon whose boiling point on the atmospheric distillation curve is transposed to the new pressure, its vapor pressure-temperature characteristics are the same as those of a normal paraffin hydrocarbon having the same boiling point. That this is not necessarily true is fairly obvious. It is also evident that if the vapor pressure-temperature characteristics differed to some extent from those of the normal paraffin of the same boiling point, the effect on the transposed distillation curve could be appreciable.

Because of this possibility it was attempted to develop a vapor pressure-temperature relation which would incorporate the chemical characteristics of the fraction as a variable. While it would be more theoretically correct to use the characteristics of the small fraction at that temperature point, i.e., one or two percent of the total fraction, the difficulty of accurately determining the exact properties of the small fraction would far outweigh the added accuracy. Therefore the characterization factor used as a correlating variable is that of the whole fraction represented by the whole distillation curve.

Figure 1 represents a plot of $\frac{P_A}{P}$ versus $\left(\frac{T}{T_A}\right)_r$ for a reference substance.

Where

P_A = atmospheric pressure in absolute units

P = any pressure in absolute units

T = boiling temperature at P in ° Rankine

T_A = atmospheric boiling temperature (at P_A) in ° Rankine

This correlation enables the determination of either the pressure, P, if the atmospheric boiling temperature and the temperature at P are known for the reference substance, or determination of the boiling temperature at P if the atmospheric boiling point and P are known.

Figure 2 correlates $\left(\frac{T}{T_A}\right)_r$ with $\left(\frac{T}{T_A}\right)_c$ (or the temperature ratio for the reference substance corrected to K = 13.0) at parameters of constant $\frac{T_A}{K}$

where

T_A = atmospheric boiling temperature in ° Rankine

K = U.O.P. characterization factor of the whole stock whose distillation curve is being considered.

The correction chart included on Figure 2 enables correction of $\left(\frac{T}{T_A}\right)_c$ to the true $\left(\frac{T}{T_A}\right)_r$ on the basis of the true characterization factor of the material.

TABLE 1
Effect of K on Computed Temperatures

	K=10	K=11	K=12	K=13
Boiling Point °F. at 50 mm	117	119	121	124
Boiling Point °F. at 760 mm	258	258	258	258
Boiling Point °F. at 100 psia	418	416	414	413
Boiling Point °F. at 50 mm	18	19	20	21
Boiling Point °F. at 760 mm	137	137	137	137
Boiling Point °F. at 100 psia	274	272	271	268
Boiling Point °F. at 50 mm	432	425	420	418
Boiling Point °F. at 760 mm	605	605	605	605
Boiling Point °F. at 100 psia	800	806	811	815

The vapor pressure data from which the Figures 1 and 2 were computed were taken from "Selected Values of Properties of the Hydrocarbons"[10] and Natural Gasoline and the Volatile Hydrocarbons.[9] Density data were derived from the same sources.

From Figures 1 and 2 vapor pressures of the pure hydrocarbons may be determined with an accuracy at 1 percent if reasonable care is exercised in reading the charts. Temperatures may be determined within ±2° F.

A comparison of temperatures resulting from transposition to sub- and superatmospheric pressures by means of Figures 1 and 2, and including the effect of K is presented in Table 1.

While the variation in temperature with K is not large (3 to 15° F. in the range shown), a considerable difference in pressure is indicated based on the normal paraffin vapor pressure chart.

Figure 3 correlates atmospheric pressure true boiling 50 percent temperature, 10-70 percent slope of the atmospheric true boiling point curve, cubic average boiling point, API gravity and K. In devising this correlation it was necessary to smooth the computed boiling point data to establish the spacing of the slope parameters. However, K values estimated from this chart are sufficiently accurate for most purposes. The principal advantage of this chart is that it enables the rapid determination of K from the TBP data and API gravity.

Example Calculations

1) Determine the vapor pressure at 550° F. of a hydrocarbon whose at-

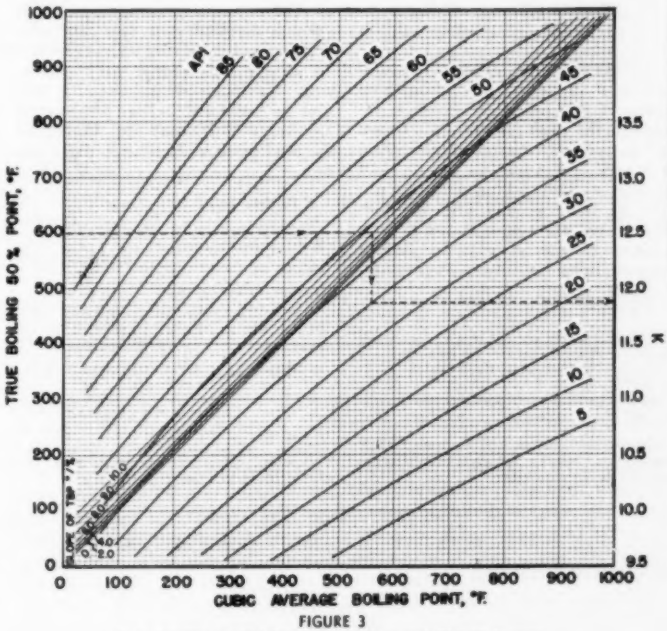

FIGURE 3
K as Function of API Gravity, TBP Slope and TBP 50 Percent.

mospheric boiling point is 400° F. and whose K = 12.0.

Solution:

$$\left(\frac{T}{T_A}\right)_t = \frac{550+460}{400+460} = \frac{1010}{860} = 1.174$$

$$\left(\frac{T}{T_A}\right)_c = 1.174 + (-0.005) = 1.169 \quad \text{(Fig. 2)}$$

$$\frac{T_A}{K} = \frac{860}{12} = 71.6$$

$$\left(\frac{T}{T_A}\right)_r = 1.186 \quad \text{(Fig. 2)}$$

$$\frac{P_A}{P} = 0.195 \quad \text{(Fig. 1)}$$

$$P = \frac{14.7}{0.195} = 75.4 \text{ psia.} \quad \text{(Ans.)}$$

2) Determine the boiling temperature at a pressure of 100 psia. of a hydrocarbon whose atmospheric boiling point is 600° F. and K = 11.0.

Solution:

$$\frac{P_A}{P} = \frac{14.7}{100} = 0.147$$

$$\left(\frac{T}{T_A}\right)_r = 1.223 \quad \text{(Fig. 1)}$$

$$\frac{T_A}{K} = \frac{600+460}{11.0} = 96.5$$

$$\left(\frac{T}{T_A}\right)_c = 1.180 \quad \text{(Fig. 2)}$$

$$\left(\frac{T}{T_A}\right)_t = 1.180 - (-0.010) = 1.190 \quad \text{(Fig. 2)}$$

$$T = (1.190)(1060) = 1261°\text{R.}$$

$$t = 1261 - 460 = 801°\text{F.} \quad \text{(Ans.)}$$

3) Determine the vaporizer temperature in a crude oil topping column where 60 percent of the crude is vaporized, the total pressure is 30 psia. and the partial pressure of the steam is 5 psia. The crude oil has an API gravity of 32.0, 50 percent TBP = 650° F. 10-70 percent TBP slope = 9.2° F./percent (slope shows F. temperature change on curve for each 1 percent change in volume vaporized).

Solution:

Using Nelson and Harvey slope and 50 percent temperature correlation:

Slope of atmospheric flash curve = 6.5° F./%

50 percent flash temperature = 586° F.

Assuming straight line flash and TBP distillation curves between 10 percent and 70 percent points:

Intersection percent of TBP and flash = 50 − X

$$650 - (9.2)X = 586 - (6.5)X$$

$$64 = 2.7X$$

$$23.6\% = X$$

Intersection = 50 − 23.6 = 26.4%

The temperature on the TBP curve at this point = 650 − (9.2) (23.6)

= 650 − 217 = 433° F.

This point may be transposed on the vapor pressure charts.

$$K = 11.7 \quad \text{(Fig. 3)}$$

$$\frac{T_A}{K} = \frac{433}{11.7} = 37$$

Vapor pressure of oil = partial pressure = 30 − 5 = 25 psia.

$$\frac{P_A}{P} = \frac{14.7}{25} = 0.589$$

$$\left(\frac{T}{T_A}\right)_r = 1.054 \quad \text{(Fig. 1)}$$

$$\left(\frac{T}{T_A}\right)_c = 1.052 \quad \text{(Fig. 2)}$$

$$\left(\frac{T}{T_A}\right)_t = 1.052 - (-0.003) = 1.055 \quad \text{(Fig. 2)}$$

$$T = (T_A)(1.055) = (433+460)(1.055) = 943°\text{R.}$$

$$t = 483°\text{F.}$$

Assuming slope of flash to be same at 25 psia. as at 14.7 psia. (slightly in error) and straight line flash curve

$$t_{60\% \text{ flash}} = (6.5)(60 - 26.4) + 483 = 701°\text{F.}$$

∴ Vaporizer temperature = 701° F. (Ans.)

4) A reduced crude having a 25 API, TBP 50 percent = 850° F., slope of TBP = 5.2° F./percent, is to be vacuum distilled at a vaporizer temperature not exceeding 680° F. so that 80 percent of the charge will be vaporized. Maximum steam quantity will give an estimated partial pressure of the steam of 20 mm. Hg. Determine the total pressure in the vaporizer section.

Solution (a):

50 percent flash temperature = 825° F. (Nelson and Harvey).

Slope of flash = 2.7° F./% (Nelson and Harvey).

Assuming straight line flash and TBP curves, the point of intersection of the curves = (50 − X)

$$850 - (X)(5.2) = 825 - (X)(2.7)$$

$$X = 10$$

50 − X = 40 percent

$$t_{40\% \text{ flash}} = 825 - (2.7)(10) = 798°\text{F.}$$

Assume total pressure = 40 mm. and check temperature.

Partial pressure of oil = 40 − 20 = 20 mm.

$$K = 12.05 \quad \text{(Fig. 3)}$$

$$\frac{T_A}{K} = \frac{798+460}{12.05} = \frac{1258}{12.05} = 104$$

$$\frac{P_A}{P} = \frac{760}{20} = 38$$

$$\left(\frac{T}{T_A}\right)_r = 0.758 \quad \text{(Fig. 1)}$$

$$\left(\frac{T}{T_A}\right)_c = 0.812 \quad \text{(Fig. 2)}$$

$$\left(\frac{T}{T_A}\right)_t = 0.812 - (0.006) = 0.806 \quad \text{(Fig. 2)}$$

$$T = (.806)(798+460) = 1015°\text{R.}$$

$$t_{40\%} = 1015 - 460 = 555°\text{F.}$$

$$t_{80\%} = 555 + (40)(2.7) = 663°\text{F.}$$

The pressure of 40 mm would be safe. To get the actual pressure assume a slightly higher pressure and repeat the above calculations.

Solution (b):

Assume the maximum temperature of 680° F. = 80 percent point on flash curve at P, and straight line flash curve.

40 percent flash temperature = 680 − (2.7)(40) = 572° F.

$$\left(\frac{T}{T_A}\right)_t = \frac{572+460}{798+460} = \frac{1032}{1258} = 0.820$$

$$\left(\frac{T}{T_A}\right)_c = 0.820 + (0.005) = 0.825 \quad \text{(Fig. 2)}$$

$$\left(\frac{T}{T_A}\right)_r = 0.769 \quad \text{(Fig. 2)}$$

$$\frac{P_A}{P} = 30.5 \quad \text{(Fig. 1)}$$

$$P = \frac{760}{30.5} = 25 \text{ mm.} \quad \text{(Ans.)}$$

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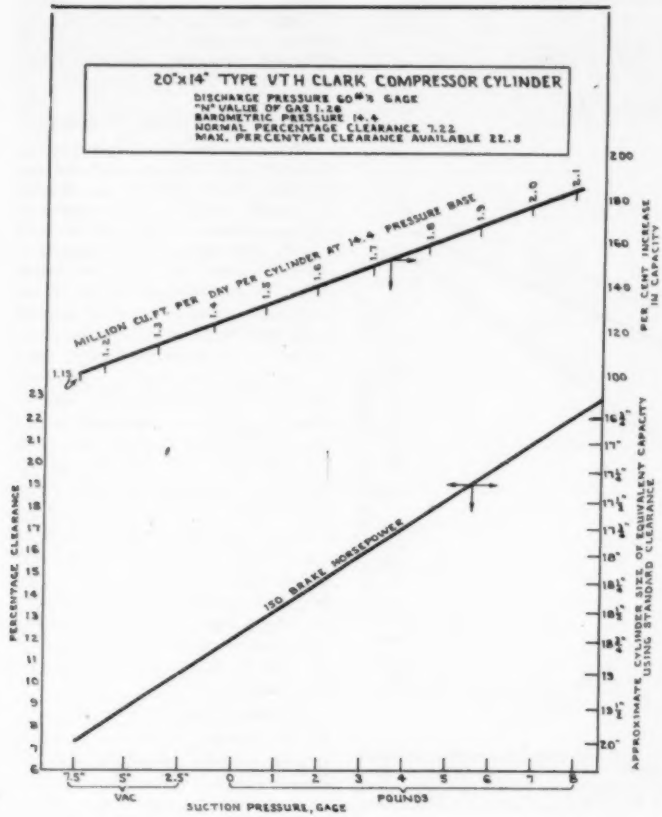
20"x14" TYPE VTH CLARK COMPRESSOR CYLINDER
DISCHARGE PRESSURE 60 LBS GAGE
"N" VALUE OF GAS 1.26
BAROMETRIC PRESSURE 14.4
NORMAL PERCENTAGE CLEARANCE 7.22
MAX. PERCENTAGE CLEARANCE AVAILABLE 22.8
MILLION CU.FT. PER DAY PER CYLINDER AT 14.4 PRESSURE BASE
150 BRAKE HORSEPOWER
PERCENTAGE CLEARANCE
PER CENT INCREASE IN CAPACITY
APPROXIMATE CYLINDER SIZE OF EQUIVALENT CAPACITY USING STANDARD CLEARANCE
SUCTION PRESSURE, GAGE
VAC
POUNDS

← Figure 1 represents results obtainable with a 20-inch by 14-inch type compressor cylinder loaded to 150 bhp. per cylinder as would be used on a 600 horsepower right-angle compressor. With 60 psig. discharge, suction pressure can be varied from 7.5 inches of mercury vacuum to 8 psig. inclusive, and capacity may be reduced to the equivalent of a 16¾-inch cylinder using standard clearances.

Operating FLEXIBILITY for Process Gas COMPRESSORS

W. R. BARRETT, Phillips Petroleum Company, Bartlesville, Okla.

***INHERENTLY**, gas compressors are inflexible with respect to changes in operating pressures, gas-handling capacities, and power output. As compressors are a major item of capital investment in many process plants, this inflexibility is a serious matter. Typical installations are custom-tailored to suit the application at hand, and alterations are costly. This article describes a new piston design which provides comparatively high flexibility in compressor operation, and without great expense. Presented first in a paper for the Natural Gasoline Association of America regional meeting at Amarillo, Texas, on December 10, the report, as published here, has been somewhat revised.*

ONE OF the most important problems involved in the design and operation of compressor plants is that of sizing compressor cylinders to best take advantage of available or anticipated operating pressure conditions.

In most instances the designer of a field compressor plant is confronted with the initial problem of comparatively large gas volumes under relatively high suction pressure and the eventual prospect that the gas will be available only at atmospheric pressure or below.

Generally the designer can only justify installation of that equipment which he is reasonably sure will be loaded throughout the time required to retire the investment so that large volumes of gas are vented to the air in the early stages of operation. Also serious damage may result to compressor equipment overloaded in an effort to handle as much gas as possible. Later it is impossible to utilize the installed horsepower due to decline in suction pressure.

In the early years of the industry, it was generally believed that any clearance in a compressor cylinder in excess of that required to avoid actual interference of reciprocating parts resulted in waste of horsepower. The purchaser of compressor cylinders demanded close clearance and maximum volumetric efficiency, while the compressor manufacturers used close clearance as one of their most effective sales arguments. Compressor cylinders were built with valves in the head, valves in hollow piston rods and other ingenious devices to give clearance as low as 1 percent. In reality these close clearances resulted in considerable waste of horsepower due to insufficient valve area and excessive pressure drop. Extremely high terminal pressures, which

Note—Phillips Petroleum Company currently licenses clearance pocket pistons both for use in new equipment and for replacement purposes.

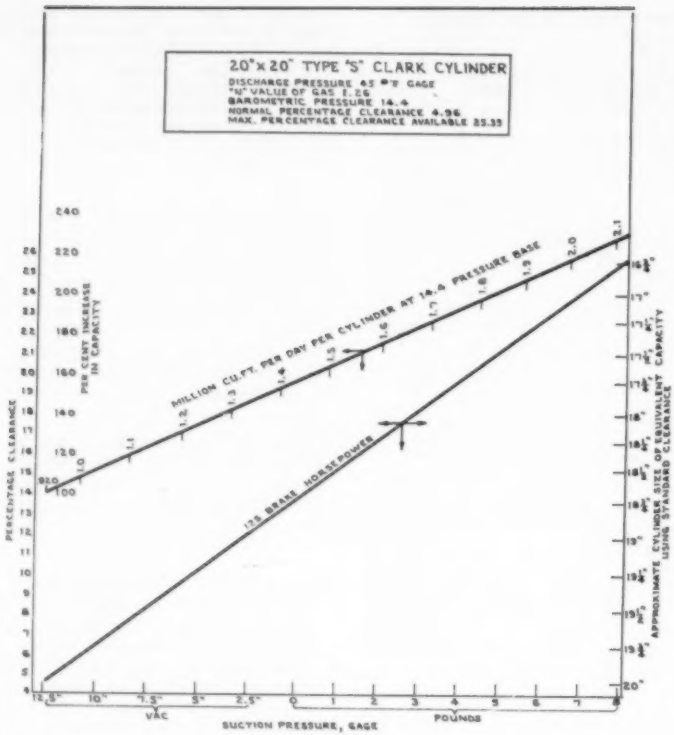
2.0"x 2.0" TYPE "S" CLARK CYLINDER
DISCHARGE PRESSURE 45 #"I" GAGE
"N" VALUE OF GAS 1.26
BAROMETRIC PRESSURE 14.4
NORMAL PERCENTAGE CLEARANCE 4.96
MAX. PERCENTAGE CLEARANCE AVAILABLE 35.33
MILLION CU.FT. PER DAY PER CYLINDER AT 14.4 PRESSURE BASE
PER CENT INCREASE IN CAPACITY
PERCENTAGE CLEARANCE
APPROXIMATE CYLINDER SIZE OF EQUIVALENT CAPACITY USING STANDARD CLEARANCE
125 BRAKE HORSEPOWER
SUCTION PRESSURE, GAGE
VAC
POUNDS

FIGURE 2

Figure 2 represents results obtainable with a 20-inch by 20-inch compressor cylinder continuously loaded to 125 bhp., as used on a 250-horsepower horizontal twin machine. With 45 psig. discharge pressure, the suction pressure may be varied from 12.5 inches mercury vacuum to 8 psig. and the capacity of the cylinder reduced to the equivalent of a 16¾-inch cylinder with standard clearances.

control the re-expansion curve, resulted in lower volumetric efficiency than if more clearance and greater valve area had been provided.

Later it was recognized that close clearance was not absolutely essential. Manufacturers began building compressor cylinders with valves in the cylinder barrel where it was possible to obtain much greater valve area for reduced pressure drop and terminal pressures. Generally accepted clearances ranged from 3 to 5 percent.

Increasing Cylinder Clearance

After considerable experimentation, designers and operators concluded that to make plant operations more flexible and to take advantage of variation in suction pressure, it was desirable to provide some means of increasing cylinder clearance. As a result they began using outside clearance pockets of various types. Some were fixed volume type, some adjustable, some were installed in the outer head only, some in both heads, and some in one or both ends of the cylinder barrel. Most of these pockets were calculated to take care of a limited variation in suction pressure. Most of the industry still believed that, although the added clearance resulted in pumping more gas without overloading the driver, there was a waste of horsepower and that better results would be obtained by changing compressor cylinder size. They also found these outside clearance pockets rather expensive, especially if it was necessary to change the size periodically.

In recent years it has been proven that the amount of clearance in a compressor cylinder has slight effect on the horsepower requirements—except where clearance percentage is so low that high terminal pressure or excessive valve pressure drop is encountered. As a result, current specifications include relatively large cylinders with clearance pocket openings. In many

TABLE 1
Volumes and Effect of Internal Chambers in Compressor Pistons

1	2	3	4	5	6	7		8		9
Size, (Inches)	Make of Compressor	Type	No. of Pockets	Vol. of One Internal Pocket (Cu. Ins.)	Total Internal Cl. Added (Cu. Ins.)	Percent Clearance		Percent Volumetric Efficiency		Reduced Size of Cylinder Using Internal Clearance (Inches)
						Normal	Maximum	Normal*	Reduced*	
10 x 20	Clark	VR	4	71.5	286.	7.04	16.5	82.9	64.25	9 x 20
10 x 20	Clark	S	S	51.4	411.2	6.1	19.5	84.7	58.25	8½ x 20
12 x 20	Clark	S	S	85.25	682.	4.6	19.95	87.9	57.30	10 x 20
14 x 20	Clark	S	S	140.	1120.	5.85	24.05	85.5	49.50	10¼ x 20
16 x 20	Clark	S	S	185.	1480.	4.58	22.98	87.8	51.20	12¾ x 20
17 x 20	Clark	S	S	215.	1720.	4.17	23.3	88.7	50.70	14 x 20
18 x 20	Clark	S	S	245.	1960.	3.87	23.39	89.1	49.70	14 x 20
20 x 20	Clark	S	10	254.6	2546.	4.96	25.39	87.1	46.30	15 x 20
20 x 14	Clark	VTH	S	166.4	1331.2	7.22	22.45	82.5	52.40	16½ x 14
23 x 14	Clark	VTH	S	278.	2224.	6.4	25.65	84.1	45.80	18 x 14
26½ x 20	Clark	S	S	535.	4380.	4.27	23.97	88.6	49.50	20 x 20
27½ x 20	Clark	S	S	587.	4696.	4.0	23.77	89.1	50.00	22 x 20
12 x 16	I-R	XRB	4	81.5	326.	7.0	16.25	83.0	64.70	10 x 16
16 x 16	I-R	XB	5	140.	700.	6.0	17.08	84.9	63.10	14 x 16
14 x 12	I-R	XVG	S	127.	1016.	10.0	37.4	76.8	22.00	7⅞ x 12

* Assuming that R : 4 and that "N" : 1.26.

NOTES:— This table is a list of compressor cylinders to which the clearance pocket type pistons have been applied. Column 4 shows the total number of pockets in each piston, column 5 shows the volume in cubic inches in each pocket, column 6 shows the total volume in all the pockets of each piston which would be divided between the head and crankcase end in operation. Column 7 is a comparison of normal percent clearance with maximum percent clearance with all pockets open. Column 8 compares volumetric efficiency, using normal clearance with volumetric efficiency and using maximum available clearance (all pockets open) in terms of percent of over-all piston displacement. Column 9 shows the nominal cylinder size having normal factory clearance to which the capacity of cylinders in column 1 may be reduced by using all clearance available in the pistons.

The values in column 7—8 are on an over-all basis. There would be a slight difference between the head and crankcase ends because of rod displacement. In calculating the values in columns 8—9, a compression ratio of 4 and a gas "N" value of 1.26 were assumed.

cases large clearance pockets are attached to the cylinder head or cylinder barrel to provide for at least a limited flexibility with respect to suction pressure and volumetric efficiency. Most of these installations, while highly desirable, are quite expensive, especially where any great amount of clearance is involved. In many cases cost of the clearance equipment is so high and benefits so limited that the operator could probably justify a change in cylinder size instead. In many cases where expensive adjustable clearance devices have been purchased and installed, a fixed clearance arrangement would have been more desirable. The adjustable feature is not used and fixed clearance is less expensive.

Overloading Problem

In modern multi-cylinder compressor units, the cylinders, especially where large sizes are used, may be so close together that outside clearance pockets can be installed in the outer head only, which creates an unbalanced condition causing excessive vibration. Operators of compressor plants have sometimes resorted to complete unloading of one end of double acting cylinders by simply removing the suction valves, in order to take advantage of higher suction pressure. In this case a considerable portion of the gain from the higher suction pressure is offset by the horsepower lost in the unloaded compression chamber. Tests indicate this loss to be from 4 to as much as 15 bhp. per cylinder depending upon displacement and compression ratio. This loss has, no doubt, often been overlooked when calculating the load, resulting in serious overloading of the driver or power end of the unit.

Oil, gas and gasoline companies throughout the country have hundreds of compressor cylinders in storage deteriorating. Many of these will be junked because they are of sizes not immediately usable. Many have no openings for adding clearance and, therefore, are worthless unless they happen to be just the size needed. In the meantime, these same companies may purchase new compressor cylinders of the required displacement to fit presently prevailing operating pressures.

What the industry has needed all along is some simple means whereby the original installation of compressor cylinders could provide the maximum displacement ultimately to be needed at minimum anticipated suction pressure, and also a means for increasing cylinder clearances so that the large gas volumes at relatively high intake pressure available initially can be handled without expensive cylinder and piping changes. The driver or power end must be fully loaded at all times to permit pumping maximum volume per horsepower installed.

Some manufacturers are presently offering compressor cylinders with removable wet type liners which provide a means of changing cylinder capacity within certain limits by replacing the liner and piston.

A compressor piston has recently been developed incorporating clearance pockets within the piston. The design is readily adaptable to any compressor cylinder having a cored or hollow piston that is large enough to allow space for such pockets. The inclosed space inside of the piston is divided by appropriate partitions into separate pockets of size and number deemed most suitable for the particular cylinder involved. Pockets may be opened to serve as additional clearance for the head end of the cylinder or for the crank end, as desired. Clearance volume may be changed as required by removing or replacing threaded plugs working through the valve parts, and without removal of the compressor cylinder heads.

Cost of Installation

Such clearance pocket type pistons may be installed at a cost slightly greater than that of conventional pistons. This is a small fraction of the cost of changing cylinders, consider-

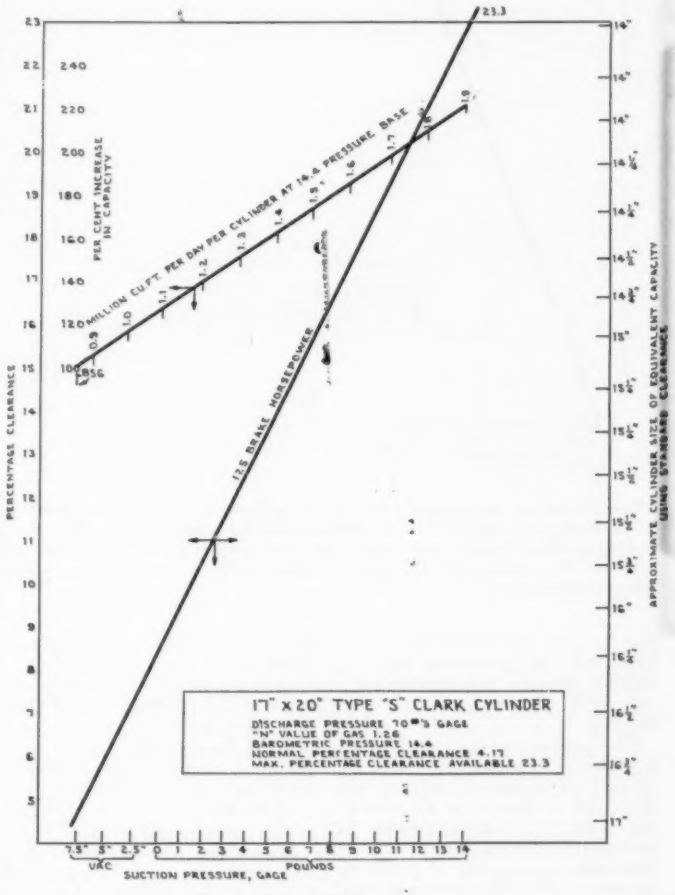
PERCENTAGE CLEARANCE
PER CENT INCREASE IN CAPACITY
MILLION CU.FT. PER DAY PER CYLINDER AT 14.6 PRESSURE BASE
125 BRAKE HORSEPOWER
17" x 20" TYPE "S" CLARK CYLINDER
DISCHARGE PRESSURE 70 PSIG GAGE
"N" VALUE OF GAS 1.26
BAROMETRIC PRESSURE 14.4
NORMAL PERCENTAGE CLEARANCE 4.17
MAX. PERCENTAGE CLEARANCE AVAILABLE 23.3
VAC
POUNDS
SUCTION PRESSURE, GAGE
APPROXIMATE CYLINDER SIZE OF EQUIVALENT CAPACITY USING STANDARD CLEARANCE

FIGURE 3

Figure 3 represents results obtainable with a 17-inch by 20-inch compressor cylinder, continuously loaded to 125 bhp., as would be used on a 250-horsepower twin horizontal compressor. With 70 psig. discharge, the suction pressure may be varied from 7.5 inches mercury vacuum to 14.5 psig. and the capacity of the cylinder reduced to the equivalent of a 14-inch cylinder with standard clearances.

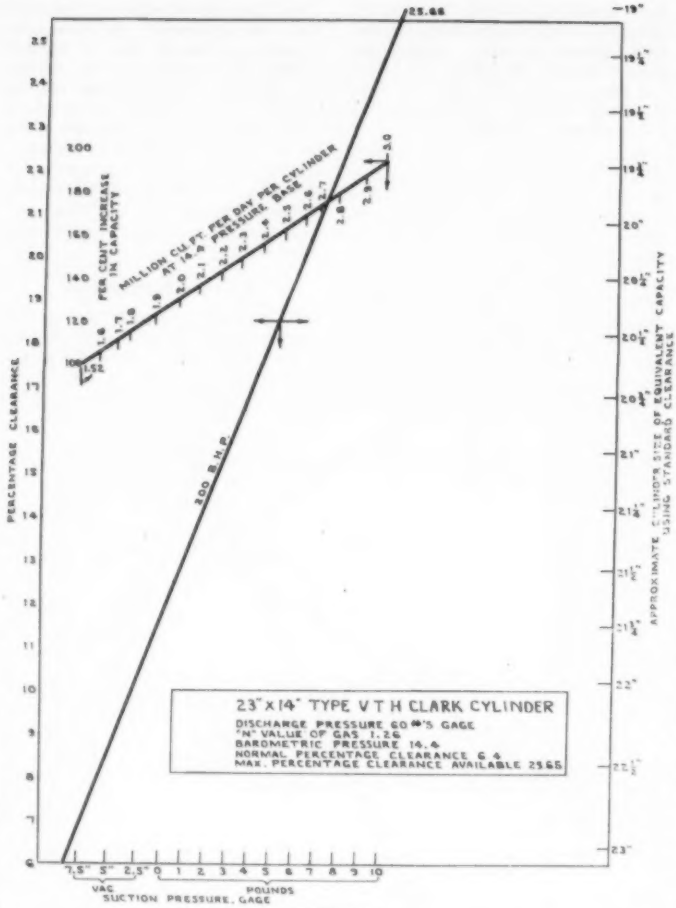
25.65
PERCENTAGE CLEARANCE
PER CENT INCREASE IN CAPACITY
MILLION CU. FT. PER DAY PER CYLINDER AT 14.4 PSIA PRESSURE BASE
1.52
200 B.H.P.
APPROXIMATE CYLINDER SIZE OF EQUIVALENT CAPACITY USING STANDARD CLEARANCE
23" x 14" TYPE V T H CLARK CYLINDER
DISCHARGE PRESSURE 60 LBS GAGE
"N" VALUE OF GAS 1.26
BAROMETRIC PRESSURE 14.4
NORMAL PERCENTAGE CLEARANCE 6.4
MAX. PERCENTAGE CLEARANCE AVAILABLE 25.65
7.5" 5" 2.5" 0 1 2 3 4 5 6 7 8 9 10
VAC
POUNDS
SUCTION PRESSURE, GAGE

FIGURE 4

Figure 4 represents results obtainable with a 23-inch by 14-inch compressor cylinder continuously loaded to 200 bhp. as would be used on an 800-horsepower right angle compressor. With 60 psig. discharge pressure, the suction pressure may be varied from 7.5 inches mercury vacuum to 10.5 psig. inclusive, and the capacity of the 23-inch cylinder reduced to the equivalent of a 19-inch cylinder with standard clearances.

ably less than that of any type adjustable pocket of comparable capacity, and less than the conventional bottle type fixed clearance pocket of equal capacity.

The operator has the added advantage that the clearance is inside the cylinder out of the way. Clearance volumes may be changed at any time by one or two men in a few minutes. No maintenance cost is involved. The clearance, when used, is fully effective. In other words, when additional clearance is used, the reduction in volumetric efficiency will be almost exactly the calculated amount.

Examples of the application of clearance volumes in these pistons are presented:

1) A gasoline plant was to be constructed involving thirty-five 250-horsepower twin horizontal gas engine compressors. Original specifications called for 0 psig. intake pressure and 55 psig. discharge pressure and the calculated capacity was 87,500 mcf at 13.45 psia.

The company had on hand 17-inch x 20-inch compressor cylinders which they decided to use. Calculations indicated that 0 psig. intake on these cylinders would overload the power end. Reducing the intake pressure to five inches of mercury vacuum would unload the power end, but obviously would reduce the capacity. Additional cylinder clearances could not be provided because the cylinders had no openings through which external pockets could be applied. The 17-inch cylinders were installed and after starting operation the compressors were seriously overloaded in an effort to avoid waste of gas.

In the meantime, the gas volume steadily increased and it developed that the producers required some 15 psig. pressure on their oil and gas separators, so there was no objection to holding 6 or 7 psig. on the compressor suction header at the plant. It appeared necessary either to install seventy new compressor cylinders of a smaller size to take gas at the higher intake pressure, or to install more compressors to handle gas which must otherwise be vented to the air. New cylinders would cost some ninety to one hundred thousand dollars and to get the same result by adding more compressor units would cost a great deal more.

Pocket Type Pistons Installed

Clearance pocket type pistons were finally installed at a cost of approximately $11,000. Using 62 percent of the clearance available in the pistons, the intake pressure was raised to 7 psig. Discharge pressure remained at 55 psig., gas pumping capacity was increased approximately 20 million cubic feet daily and horsepower requirements were reduced to well within the rating of the units. By using the remaining available clearance in these pistons the intake pressure could be raised to a maximum of 14 psig. without overloading the engines.

Most of the 17-inch compressor cylinders installed in this plant had been rebored and fitted with new conventional type pistons; had the clearance pocket type piston been used instead, the cost would have been only $2500 more than the cost of conventional pistons.

2) A booster compressor plant was planned involving five 600-horsepower right-angle compressors. It was impossible to determine what the intake and discharge pressures would be. It was anticipated that for the first year or two gas might be received at suction pressures around 20 to 30 psig. Discharge pressure would depend to a large extent on volume handled and discharge line pressure drop. It was agreed that the suction pressure would eventually be reduced to 0 psig., at which time 20-inch bore compressor cylinders would be needed. It was finally decided that 14-inch cylinders would be the best guess for initial operation.

The cost of 14-inch cylinders includ-

ing later piping changes was estimated at $60,000. It was anticipated there would be no market for the cylinders when taken out of service.

By using clearance pocket type pistons in 20-inch bore cylinders, with discharge pressure at 60 psig., intake pressure up to and including 8 psig. could be handled without overloading the power end.

It later developed that gas could be obtained at higher pressure than 8 psig., and by unloading the crankcase end of each compressor cylinder and using maximum available clearance on head end, suction pressure up to 45 psig. and discharge pressure of 80 psig. were handled, pumping a maximum volume of 72 million cubic feet daily. The original estimate was 54 million cubic feet per day.

Keeping Engine Loaded

Tests on the unloaded crankcase end of compressor cylinders revealed a loss of 8 bhp. per cylinder or 32 bhp. per compressor. While unloading of cylinders by removal of suction valves was used in this case, results could not be duplicated without the clearance pocket type piston. The load is equally distributed to all cylinders. As suction pressure declines it can be kept equally distributed by closing off clearance until all pockets have been plugged, after which all pockets will be opened up again and the crankcase end of cylinders loaded up. As further decline occurs, pockets will again be plugged as necessary to keep the engine fully loaded.

An important feature in both of these cases is that as the suction pressure declines, the clearance arrangement can be gradually changed to take full advantage of available suction pressure, the power end being fully loaded at all times. This cannot be accomplished by other methods except at great expense. In a number of cases recently, when specifications called for 14-inch diameter cylinders, 17-inch cylinders with clearance-pocket type pistons were used. In these cases, as in the first example, the 17-inch cylinders were on hand. In cases involving purchase of new cylinders, the largest size anticipated for eventual operations, equipped with clearance-pocket type pistons, can be specified. In cases where old compressor cylinders are rebored, or new pistons installed for any reason, the clearance type pistons can be user to good advantage. Then should clearance ever be needed in the present location, or elsewhere, it is available in the cylinder.

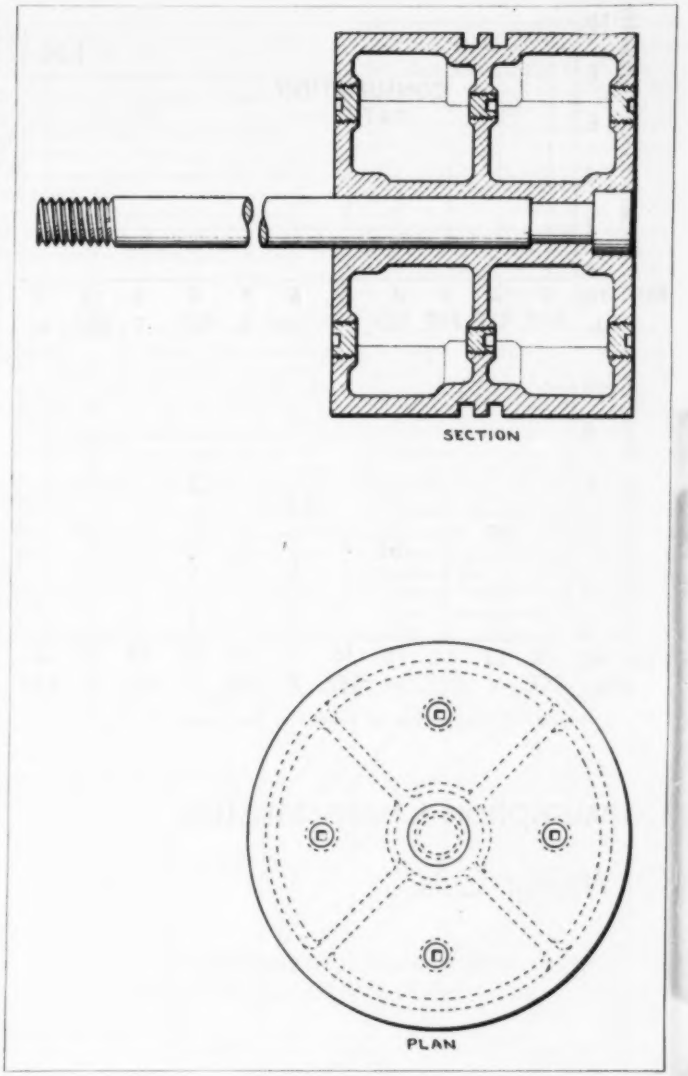

FIGURE 5

Figure 5 is a sketch showing a typical clearance pocket type piston. Arrangement of the pockets varies depending upon the size and shape of the piston involved and the amount of clearance desired in each pocket for the purpose of providing flexibility.

* * *

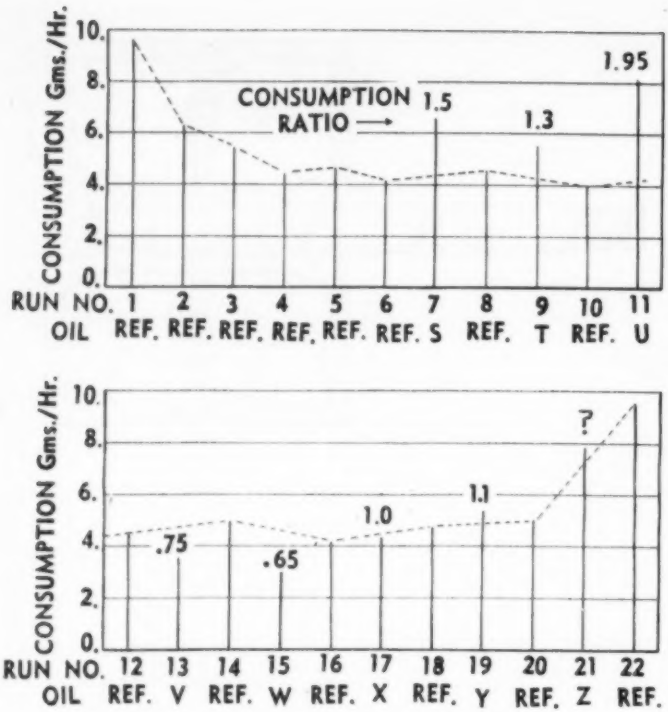

FIGURE 1—Typical Series of Oil Consumption Tests. Lauson H-2 Engine

Consumption Characteristics Of Motor Oils

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OIL consumption tends to be the chief "yard-stick" by which many motorists and operators judge oil quality. The amount of oil consumed, and how much must be added between customary crankcase drains, is the most readily apparent performance characteristic of motor oils insofar as the average user is concerned.

The properties of motor oils which have the greater affect on consumption tendencies (volatility, viscosity, and Viscosity Index), are very difficult to isolate and study separately, since they are to a large extent inter-dependent. Thus for example, oils of low viscosity tend to be more volatile than more viscous grades. Similarly, oils of low Viscosity Index tend to contain more volatile constituents than high V. I. oils of similar viscosity. In conducting this consumption test program, an attempt was made to isolate the three most important variables to the greatest extent possible, so that the influence of each could be identified within practical limits.

Laboratory Consumption Tests

Preliminary work on developing a laboratory engine test method for evaluating oil consumption characteristics indicated that multi-cylinder engines of commercial types tended to display considerable variations in consumption values in spite of the closest possible control of engine condition and operation. In order to minimize engine variables to the optimum possible extent, a single cylinder test engine was finally selected (Model H-2 Lauson oil test engine). Details of the test procedure are given in Appendix 1. Engine operating conditions chosen may be described as moderate as to speed, load and temperatures, and during the 20-hour test period oil oxidation was negligible with all but very unstaple types of motor oils. Emphasis was thus placed upon consumption and the physical properties of oils relating thereto, rather than upon oil stability, oxidation resistance, detergency, etc.

Figure 1 illustrates results of a typical series of consumption tests. As shown, the first three tests with the Reference oil were necessary to run in the engine and to establish consumption at a basic level. The next three tests then establish the basic consumption pattern for the Reference oil in the given engine set-up. The Reference oil in all cases was an SAE 10-grade of 48 seconds Saybolt viscosity at 210° F., and 110 V. I.) After the initial calibrating runs, tests on oils of unknown consumption characteristics are then alternated with runs on Reference oil. After 20 test runs on this particular engine set-up, consumption results became erratic and the series was terminated for engine overhaul.

Since different engine set-ups developed basic consumption patterns varying from 3 to 6 grams per hour, consumption values on unknown oils must thus be reported as "consumption ratios" rather than in actual quantities, such as grams per hour. It is interesting, however, that by this method repeat tests on many oils in different test engine set-ups checked within the same limits of reproducibility as did repeat tests on the same oil in the same engine set-up. It will be noted that even under nearly ideal conditions of test as to control of engine and operation uniformity, consumption values on the Reference oil vary by some 20 to 25 percent. This may be taken as factual evidence it is extremely difficult to evaluate motor oil consumption characteristics with a high degree of precision.

Oil Volatility—Consumption Relation

Figure 2 summarizes the results of a series of tests to study the relation of oil volatility to consumption. The test oils were all of SAE 10-grade, 48

IN SPITE of the practical importance of motor oil consumption characteristics, relatively little data on the subject appear in technical literature and much of this is contradictory. (See references, page 000.) The reason is the extreme difficulty experienced in evaluating oil consumption properties comprehensively and accurately.

Factors which govern the amount or rate of oil consumption in any given engine are shown in Table 1. Mechanical defects in the engine as well as physical deficiencies in the oil would, of course, have their effects. So this paper discusses oil consumption as related to the physical properties of motor oils and is confined to studies in engines in good mechanical condition.

Presentation was at the SAE National Fuels and Lubricants meeting in Tulsa, November 4-5, 1948.

TABLE 1
Causes of Excessive Oil Consumption

MECHANICAL DEFECTS

Piston Condition—Worn ring grooves, collapsed skirts.

Piston Ring Condition—Worn, loss of tension, excessively tight or loose fit in grooves, compression rings stuck, or oil rings plugged.

Cylinder Wall Condition—Worn, distorted, or scored.

Valve Condition—Worn valve guides or stems. Excessive oil supply to valve train.

Bearing Condition—Worn or loose bearings allowing excessive oil throw-off to cylinder walls.

Leaks—Gaskets improperly seated, defective or broken. Worn or defective shaft Seals. Loose plumbing on oil filter and exterior oil lines. Excessive crankcase pressure. Excessive crankcase ventilation or defective eductor pipe.

Fuel Pump—Leaking diaphragm in fuel—vacuum booster pump. Defective fuel pump drive arm seal.

Overfilling of Crankcase—Too high oil level, causing excessive splashing and throw-off on cylinder walls.

Excessive Fuel Dilution of Crankcase Oil—From defective carburetion or too low engine jacket and crankcase temperatures.

OPERATING CONDITIONS

Engine Speed—High engine or vehicle speeds.

OIL PROPERTIES

Volatility—Oil containing excessive portion of volatile constituents.

Viscosity—Oil of inadequate viscosity for the engine operating speeds and temperatures.

Viscosity Index—Excessive "thinning-out" of the oil on exposure to elevated temperatures.

seconds Saybolt viscosity at 210° F., and had V. I. between 108 and 115, which was as close as could be attained with the various volatility ranges. Oil "volatility" is indicated by the vacuum distillation curves (5 millimeters mercury absolute pressure).

Based on these data, the Reference oil and oils A and B have substantially identical consumption characteristics. It appears therefore that "volatility" is a minor factor in consumption with oils distilling above about 380° F., at 5 mm. mercury (approximately 680° F. corrected to atmospheric pressure)*.

From the initial oil change in the engine and the total oil consumed during the tests, it is possible to estimate the percent of oil which was apparently lost by "volatility" to account for the higher consumption in the case of oils C, D, and E. From such estimates it is indicated that any constituents of an oil which distill below about 360° F. at 5 mm. mercury (approximately 660° F. corrected to atmospheric pressure) may readily be lost by evaporation when used in engines. It appears accordingly that a 5 mm. vacuum distillation temperature in the order of 360° - 380° F. (approximately 660°-680° F. corrected to atmospheric pressure) may be the distinguishing line between "volatility" and "non-volatility" as far as consumption is concerned. Oils which contain no constituents distilling below this temperature range apparently do not have added consumption tendencies from "volatility."

Although there is no precise correlation between flash points and vacuum distillation ranges of motor oils, the data developed from these tests indicate that oils having flash points above 380° to 400° F. may be considered as satisfactorily "non-volatile." While this conclusion is based upon the laboratory data from one make of engine run under a specific set of operating conditions, it is in good agreement with other published statements (see references) and is confirmed by general industry practice and experience.

Figure 3 summarizes results of tests to study the relation of oil viscosity

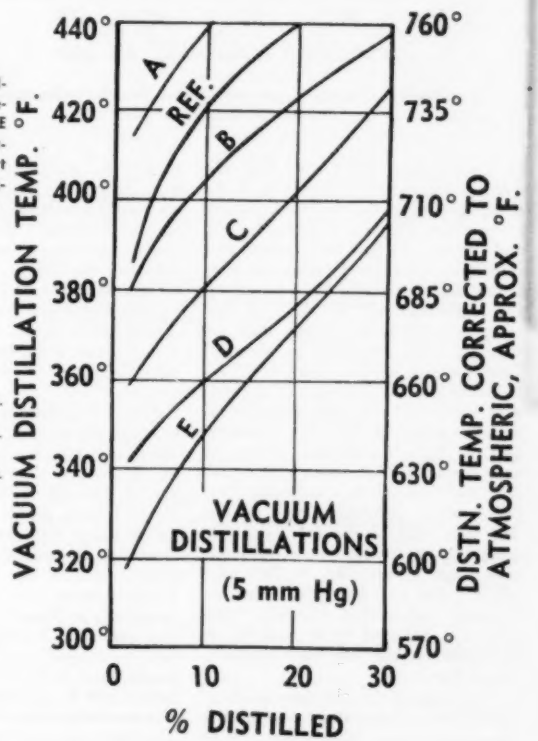

FIGURE 2—Volatility-Consumption Relation. (All oils SAE 10 grade, 48 Sec. Saybolt Viscosity at 210°F., Viscosity Indexes 108 to 115)

Consumption ratio of oils:

A—1.0, .95, 1.0, 1.05. Ref.—1.0.

B—1.05, 1.0, 1.0, .95.

C—1.2, 1.1, 1.2.

D—2.0, 1.9, 1.8, 1.9.

E—2.3, 2.5.

* Vacuum distillation temperatures on lube oils will vary quite appreciably depending upon the design of distillation apparatus, distillation rate, reflux ratio, etc. The temperature values given above apply to the particular apparatus and procedure used and may vary materially if determined in other designs of stills, even though operated at the same vacuum.

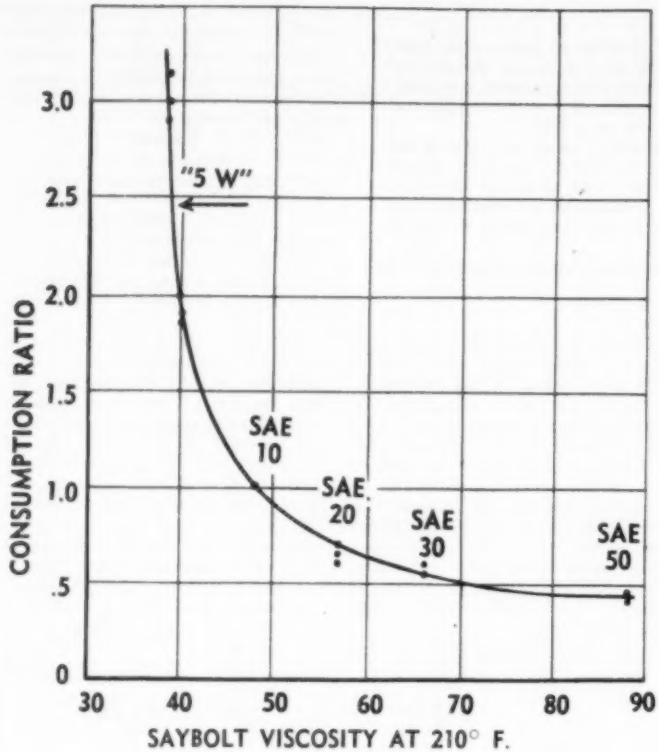

FIGURE 3—Viscosity-Consumption Relation. (All oils of same type and with Viscosity Indexes from 105 to 115

to consumption. All of the test oils were of 105 to 115 V. I., the V. I. decreasing progressively with increases of viscosity. The oils of SAE 10-grade and heavier all had flash points and distillation curves well above the minimum limits indicated to be necessary for "non-volatility," so that the consumption differences shown may be taken as due essentially to viscosity. The two oils in the proposed "5W" viscosity range contained an appreciable portion of "volatile" constituents as necessitated by their low viscosity, and the high consumption values are thus due to a combination of "volatility" and viscosity. It is estimated from the vacuum distillation curves that less than half of the increased consumption of the two very light oils above that of the SAE 10 Reference oil was due to "volatility." The low viscosity, rather than excessive "volatility" is believed to be largely responsible for the very high consumption values.

The shape of the viscosity-consumption curve is interesting, especially in the region below 48 seconds Saybolt at 210° F., and indicates the importance of suitably viscous oil films for maintaining adequate piston and ring sealing. A viscosity change of only one Saybolt second or less is apparently sufficient to cause a large change in oil consumption in the range of 40 seconds and lower. Oil viscosity in the region below about 40 seconds Saybolt is thus indicated to be a very critical factor in consumption tendencies.

Figure 4 summarizes results of tests to study the relation of V. I. to consumption. All of the test oils were of 48 second Saybolt viscosity at 210° F. The oils of 38 V. I. and higher all had flash points and distillation curves above the minimum limits indicated to be necessary for "non-volatility," so that the consumption differences shown may be taken as due essentially to Viscosity Index. The oils of 6 and 16 V. I. respectively had low flash points and contained appreciable percentages of constituents distillating below 360° F. at 5 mm. mercury, as is characteristic of oils in this V. I. range. The high consumption values for the two lowest V. I. oils is thus due to a combination of "volatility" and V. I. which evidently accounts for the sharp "hook" in the curve below 38 V. I. From the vacuum distillation curves of the two low V. I. oils, corrections can be estimated for the "volatility" factor, to indicate the approximate effect of V. I. alone, as shown on Figure 4.

Based on these data, oils of very low V. I. may have as much as 50 percent higher consumption tendencies compared to high V. I. oils, omitting any effects of "volatility." This difference may be attributed to the fact a high V. I. oil will be from 1 to 3 Saybolt seconds higher in viscosity than a low V. I. oil at the temperatures existing in the ring zones of running engines (300° to 500° F.), although both oils have the same viscosity at 210° F. Since all oils thin out to viscosities of 40 seconds Saybolt or less at temperatures of 300° to 500° F., a difference of only one or two seconds in viscosity within this range due to differences in V. I. may have a significant effect on consumption tendencies, as indicated from the data in Figure 3.

Viscosity Index Improvers

Motor oils of high V. I. are desirable for numerous well recognized reasons, and the trend in motor oils over the past decade has been distinctly to higher V. I. products. Since V. I. in the order of 110 to 115 represent the upper limit economically obtainable with straight petroleum oils, V. I. improving additives are of great interest and are becoming more and more utilized in motor oil formulations. Since V. I. is indicated to be an important factor in oil consumption characteristics, the very high V. I.'s obtainable with improver additives suggest interesting possibilities. A rather extensive study of the effect of V. I. improvers on oil consumption tendencies was accordingly undertaken.

Table 2 summarizes consumption test results on a high V. I. SAE 10-base oil treated with three different types of commercial V. I. improving additives. Sufficient concentrations of the three respective additives were incorporated to increase the finished oil viscosities to the range of the SAE 20 grade.

V. I. improvers "X" and "Z" effected no change in consumption properties from the base oil alone, in spite of the materially higher viscosities and very high Viscosity Indexes of the two treated oils. V. I. improver "Y" apparently produced a slight reduction in consumption, although it was not as effective in this regard as the addi-

TABLE 2

Laboratory Oil Consumption Tests

Effect of Viscosity Index Improvers on SAE 10 High Viscosity Index Base Oil

	Saybolt Viscosity at 210° F.	Viscosity Index	Consumption Ratio
SAE 10 Reference Oil	48.0	110	1.0
Reference Oil Plus V. I. Improver "X"	56.8	132	1.0, 1.0
Reference Oil Plus V. I. Improver "Z"	56.8	130	1.1, 1.0, 1.05
Reference Oil Plus V. I. Improver "Y"	56.8	123	.8, .9, .8
Reference Oil Plus Petroleum Bright Stock	56.8	106	.6, .7

TABLE 3

Laboratory Oil Consumption Tests

Effect of Viscosity Index Improvers on "5W" Base Oil

	Saybolt Viscosity at 210° F.	Viscosity Index	Consumption Ratio
SAE 10 Reference Oil	48.0	110	1.0
"5W" Base Oil	40.0	115	1.9, 1.85, 2.0
"5W" Base Oil Plus V. I. Improver "X"	47.7	155	2.0, 1.9
"5W" Base Oil Plus V. I. Improver "Z"	47.9	152	2.1, 1.9
"5W" Base Oil Plus V. I. Improver "Y"	47.9	142	1.7, 1.8
"5W" Base Oil Plus Petroleum Bright Stock	48.1	114	1.6

tion of a petroleum bright stock to secure the same 210° viscosity but with a much lower V. I.

The oil drains from the 20 hour engine tests on all of the V. I. additive containing oils were checked for viscosity and V. I. to determine if permanent changes from break-down of the polymers during use would account for their poor showing. In all cases the drain oils tested almost identical to the original blends in viscosity properties, and V. I. values declined only 2 or 3 units at most. Permanent changes in viscosity properties of the oils containing V. I. improvers were thus not a significant factor, and do not account for the results obtained.

Table 3 summarizes consumption test results on a "5W" grade base oil treated with the same V. I. improving additives. In this series the "5W" base oil of 40 seconds Saybolt viscosity at 210° was treated with sufficient of the respective additives to increase the viscosities of the finished oils to 48 seconds at 210° to be the equivalent of the SAE 10 Reference oil. Again, and in spite of the very high V. I., additives "X" and "Z" effected no improvement over the "5W" base oil alone. Additive "Y" displays a limited degree of improvement, but is not as effective as the addition of petroleum bright stock to obtain the same 210° viscosity and only 114 V. I.

Table 4 shows consumption test results on a low viscosity, low V. I. pale

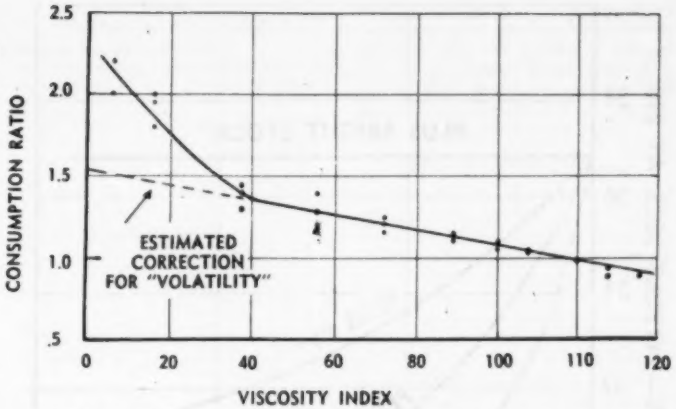

FIGURE 4—Viscosity Index-Consumption Relation. (All oils 48 Sec. Saybolt Viscosity at 210°F.)

oil. The data again indicate no improvement from the V. I. additive, although significant improvement was attained by addition of petroleum bright stock to increase the viscosity at 210° F. to the same degree, but with only a negligible increase in V. I. It is probable that the consumption improvement effected by the addition of bright stock was due in part to a reduction of the over-all volatility of the oil blend, since a relatively large amount was required to increase the 210° viscosity to the same extent obtained with only 4 percent of the V. I. improver.

In the preceding tests, the various petroleum base oils were treated with quite high concentrations (3 to 8 percent) of the respective V. I. improvers in order to secure the increments in 210° viscosity desired for comparison purposes. Table 5 lists results of a series of consumption tests to study the effect of more moderate additions of V. I. improvers. The low viscosity base oil displays very high consumption through a combination of "volatility" and inadequate viscosity. Addition of a small amount of petroleum bright stock or of 1 percent V. I. improver "X" reduced consumption materially. Evidently the small increase in viscosity from 38.6 to 40 seconds at 210° as effected by either bright stock or V. I. improver was sufficient to take the base oil out of the most critical range of the viscosity-consumption relation. As shown by Figure C, in the viscosity range below about 40 seconds Saybolt, a change in viscosity of one second or less may

TABLE 4

Laboratory Oil Consumption Tests—Effect of Viscosity Index Improvers on Low Viscosity Index Base Oils

	Saybolt Viscosity at 210° F.	Viscosity Index	Consumption Ratio (SAE 10 Reference Oil = 1.)
Low V. I. Pale Oil	39.8	6	3.5
Low V. I. Pale Oil Plus 4. percent V. I. Improver "X"	48.1	114	3.5
Low V. I. Pale Oil Plus 22. percent Low V. I. Bright Stock	47.8	16	2.0, 1.8, 1.95

TABLE 5

Laboratory Oil Consumption Tests—Effect of Limited Concentrations of Viscosity Index Improvers

	Saybolt Viscosity at 210° F.	Viscosity Index	Consumption Ratio (SAE 10 Reference Oil = 1.)
Low Viscosity Base Oil	38.6	106	2.9, 2.7
Base Oil Plus Petroleum Bright Stock	40.0	116	1.9, 2.1
Base Oil Plus 1 Percent V. I. Improver "X"	40.0	125	2.0, 2.1
Base Oil Plus 4½ Percent V. I. Improver "X"	48.1	156	2.0, 1.9
SAE 10 Reference Oil	48.0	110	1.0
Reference Oil Plus 1 Percent Improver "X"	50.9	124	.95, 1.0
Reference Oil Plus 4 Percent Improver "X"	56.8	132	1.0, 1.0

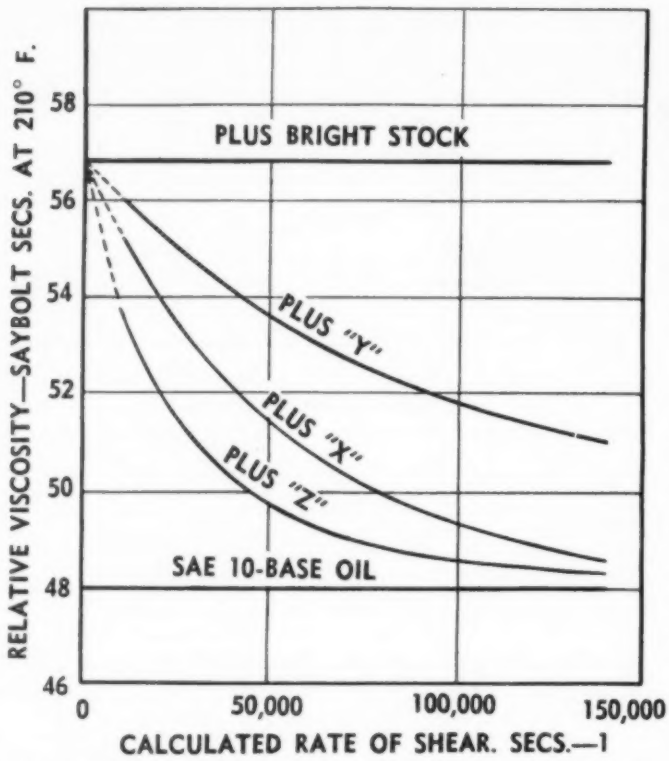

FIGURE 5—Relative Viscosities at High Rates of Shear and Effect of Viscosity Index Improvers (Same oils as listed in Table 2)

make a great difference in consumption, and in this very critical region small additions of any viscosity increasing material may thus have a very marked effect. On the other hand, addition of a much larger amount of improver "X" produced no consumption improvement over that achieved with 1 percent. With the larger addition, the oil viscosity of 48 seconds at 210° is well above the most critical range, so that other factors of volatility, plus certain fundamental limitations of V. I. improvers discussed later, apparently place a limit upon the improvement which can be achieved.

No Noticeable Change

In the case of the SAE 10-base oil, neither small nor large additions of V. I. improver effected any noticeable change in consumption. Again, since the base oil of 48 seconds viscosity is above the most critical range, other factors relating to basic limitations in V. I. improving additives evidently predominate.

On the basis of the laboratory engine test data, V. I. improvers are indicated to have very distinct limitations, and do not decrease oil consumption characteristics to the extent which might be indicated from a literal interpretation of the viscosity and V. I. values obtained in the customary manner by means of Saybolt or glass tube kinematic viscosimeters.

Viscosity—Rate of Shear Relation of Oils Containing V.I. Improvers

In an attempt to find reasons why the V. I. improvers did not improve motor oil consumption characteristics to any significant extent, a limited amount of work was done with a rotary, thin film viscosimeter to determine the relative viscosities of oils at high rates of shear. A brief description of the apparatus used is given in Appendix 2.

Figure 5 shows relative Saybolt viscosities at 210° F. of a typical series of oils at rates of shear up to 140,000 reciprocal seconds. With the type of apparatus used, a basic assumption must be made that straight petroleum oils are Newtonian fluids at 210° F., and hence have constant viscosities irrespective of the rate of shear. On this basis, the SAE 10-base oil of 48 seconds Saybolt at 210° and the base oil —petroleum bright stock blend of 56.8 seconds at 210° are straight lines on the graph. By comparison, the three oils made from the SAE 10-base oil plus the three respective V. I. improvers to a viscosity of 56.8 seconds at 210° are curves, with the viscosities decreasing with increasing rates of shear. Relatively, therefore, the oils containing the V. I. improvers are shown to be Non-Newtonian fluids, and decrease sharply in viscosity at high shear rates while at constant temperature.

No Permanent Change

It is noteworthy that the curves for the SAE 10-base oil plus additives "X" and "Z" approach substantially the viscosity of the straight base oil at shear rates above 100,000 reciprocal seconds, while the base oil plus additive "Y" shows materially better viscosity-shear stability. It should be mentioned that this viscosity change with rate of shear does not represent a permanent change in the viscosity of the V. I. improver treated oils. The same oil after test at high shear rates in the rotary viscosimeter can be recovered and tested in a conventional glass tube viscosimeter and will have substantially the same viscosities and V. I. as the original oil blend.

One of the most interesting features of this investigation is the correlation between the viscosity-shear data as shown in Figure 5 and the oil consumption data given in Table 2. Additives "X" and "Z" which display the poorest viscosity-shear stability and indicate practically nil viscosity effect at high shear rates also showed essentially nil improvement in the engine consumption tests. On the other hand, additive "Y" which displays appreciably better viscosity - shear stability also showed a corresponding degree of improvement in consumption tendencies.

In any event, the data indicate that petroleum oils containing V. I. improvers are Non-Newtonian fluids and on exposure to high rates of shear tend to approach the viscosity of the original base oil. This conclusion seems to be the only one which accounts for the indicated inability of V. I. improvers to improve motor oil consumption characteristics to any significant extent above that of the base mineral oil.

Although rates of shear in the order of 100,000 or more reciprocal seconds may seem to be high, the rate of shear on the oil films in a typical engine bearing at 2000 r.p.m. is some 200,000

reciprocal seconds with an assumed clearance of .001-inch. Similarly, the rate of shear on the oil films between piston rings and cylinder walls in a typical engine running at 2000 r.p.m. is some 300,000 reciprocal seconds with an assumed clearance of .001-inch. Since running clearances in engine and on cylinder walls are probably much less than .001-inch, shear rates, will be correspondingly higher, and have been estimated as high as several million reciprocal seconds. It can be concluded, therefore, that very high rates of shear are developed in engines and that these are responsible for the limited effectiveness of V. I. improving additives.

Complex Polymers of High Molecular Weight

V. I. improvers are complex polymers of very high molecular weight, characterized by a long straight chain structure with short side groups. A polymer-mineral oil blend may thus be likened to a handful of spaghetti mixed into a cup of peas, the spaghetti representing the polymer molecules and the peas the oil molecules. At very low rates of flow, such as pouring the mixture from a cup, which may be considered the equivalent of low rates of shear, the spaghetti is heterogeneously mixed with the peas and forms a criss-cross matrix to impede flow of the peas. This hindrance of flow is equivalent to an apparent increase in viscosity. At very high rates of flow, such as forcing the spaghetti-pea mixture through a pipe at high velocity, which corresponds to high rates of shear, the strings of spaghetti will tend to become oriented parallel with the direction of flow, and will thus offer less impedance to the flow of the peas. This greater flowability is then the equal of an apparent decrease in viscosity, although the mixture is not altered as to composition or temperature, and the only change being that of rate of motion. Although an apology is due for this excursion into kitchen chemistry, a mixture of peas and spaghetti seems to represent a reasonable analogy to a mineral oil-polymer blend and may aid in visualizing why large differences in viscosity can occur in such a blend with no physical or chemical change other than rate of flow or shear.

Laboratory Values Only

In Saybolt or glass tube kinematic viscosimeters, rates of shear are very low, usually less than 100 reciprocal seconds, so that these customary laboratory viscosity determinations indicate the maximum alterations of apparent viscosity capable of being caused by V. I. improving polymers.

TABLE 6
Road Tests on Oil Consumption

Effect of Driving Conditions:

Type of Driving	Car A	Car B
500 miles in city operation, SAE 10 Reference Oil	1400 miles per quart	Over 2000 miles per quart
400 miles high speed country operation, SAE 10 Reference Oil	320 miles per quart	500 miles per quart

Effect of Engine Condition:

	Car C	Car D
	1940 Model Used 65,000 miles	1947 Model Used 8,000 miles
"High Consuming" Oil	190 miles per quart	380 miles per quart
"Low Consuming" Oil	220 miles per quart	720 miles per quart

TABLE 7
Road Tests on Oil Consumption

Effect of Oil Volatility:

	Consumption Ratio		
	Min. Difference	Max. Difference	Average Difference
SAE 10 Reference Oil, 48 Sec. at 210° F., 110 V.I.	1.0	1.0	1.0
SAE 10 "Volatile" Oil, 48 Sec. at 210° F., 115 V.I. (Oil D, Figure B)	1.1	1.8	1.3

At the very high rates of shear developed in engines, essentially the opposite prevails, and the polymers are indicated to cause a minimum of change in the base oil. Consequently the customary laboratory determined viscosity increases and very high V. I. as imparted to petroleum oils by these polymers are nothing more than laboratory values which may have very limited significance in engines. The evaluation of the viscosity characteristics of Non-Newtonian fluids can thus become very complex, since three rather than two variables are involved (viscosity, temperature, and rate of shear), and erroneous assumptions can readily be reached if this third factor is not properly appreciated.

Road Tests on Oil Consumption

Laboratory engine tests for studying motor oil consumption characteristics are subject to criticism, since laboratory methods are directed to optimum possible uniformity and control of engine and operating conditions, which is exactly the opposite of operation on the road. The relation or correlation of test results obtained under closely controlled and uniform laboratory conditions compared to service conditions, which fluctuate widely and continuously may thus be questioned. Similarly, the relation between results secured in one make of engine under one set of closely defined operating conditions contrasted to road service in many different makes of engines may be questioned. Consequently laboratory data on oil consumption may have limited significance in the absence of related road test data.

Difficulty of Road Tests

Since accurate consumption data are difficult to obtain even in the laboratory under ideal conditions, road data of acceptable significance are vastly more difficult to get. Because of the greatly increased number of variables on the road, tests on only a few vehicles may be greatly misleading, and statistical averages of a large number of vehicle tests are really necessary for dependable information. The difficulty of obtaining accurate road test data on oil consumption is illustrated in Table 6. Illustrating the effect of driving conditions; two cars were run exclusively in city operation for 500 miles each; following which they were taken on country runs of 400 miles where road speeds of 50 to 70 miles per hour were maintained as much of the time as possible. The wide differences in consumption, with the same Reference oil, indictate the importance of driving conditions, and the variations in results which can occur if this variable is not controlled.

Affect of Speed on Oil Consumption

Engine or vehicle speed probably has a greater affect on oil consumption tendencies than any other single factor. The laboratory engine test data as summarized in Figures 2, 3 and 4 indicate a consumption increase of some 250 per cent between the least volatile oil and the most volatile oil tested; about 100 per cent increase in consumption between the SAE 30 and SAE 10 oils of similar basic properties; and about 50 percent increase in consumption between a 110 V. I. oil and a 0 V. I. oil. On the other hand, the road tests per Table 6 show some 400 percent change in oil consumption between low speed and high speed driving. While the consumption-speed relation may vary considerably in different engines it is characteristically of large magnitude. Graves[2] has shown that increasing average driving speed from 30 to 50 miles per hour may cause consumption increases from 2 to 10-fold. Similarly, the shop manual of one car manufacturer mentions that increasing average driving speed from 30 to 60 miles per hour may increase oil consumption some 2½ times, and in going from 20 to 80 miles per hour, consumption may be 5 times as great.

Another important variable on the

road is the fact some engines are relatively insensitive to differences in oils, whereas others show marked changes in consumption with oils of different types. Engine conditions as to age and wear is probably the chief reason for such, although engine design and type of operation also has a bearing. As shown on Table 6, Car C displayed relatively little difference between two oils of quite different consumption characteristics, whereas Car D shows almost a two fold consumption difference between the same two oils, although the conditions of operation of both cars as to speeds and type of driving were substantially similar during the test intervals.

Road tests to study oil consumption accordingly require careful interpretation, as well as careful selection of test vehicles as to uniformity of operating conditions throughout the test program. The road test results reported herein were as carefully controlled and supervised as possible, consistent with the limitations of normal vehicle usage on the road, and represent some 300,000 miles in 23 cars and trucks. Although this is not as extensive a program as might be desired for comprehensive statistical averages, a large amount of work was involved and the results are believed to be reasonably indicative.

Road Tests

In conducting the road tests, the consumption with the SAE 10 Reference oil was used as the base line for each vehicle and consumption with the other test oils is reported as "consumption ratio."

Table 7 summarizes results of tests on the effect of oil "volatility" on consumption. As shown the "volatile" SAE 10 oil varied from 1.1 to 1.8 consumption ratio, or 10 to 80 percent higher consumption than the SAE 10 Reference oil; with an average ratio in all vehicles of 1.3, or 30 percent higher consumption. This compares with a ratio of 1.9 in the laboratory engine tests per Figure 2. While the maximum difference on the road is in good agreement with the laboratory value, the average road difference is considerably less than the laboratory result, but still indicates that "volatility" is a significant factor in oil consumption tendencies.

The wide variation in road test results is significant and indicates the importance of adequate road data in evaluating consumption characteristics. Thus based upon single tests, the conclusion could be either that oil "volatility" makes essentially no difference in consumption, or an almost two fold difference.

TABLE 8

Road Tests on Oil Consumption

Effect of Oil Viscosity:

	Consumption Ratio		
	Min. Difference	Max. Difference	Average Difference
SAE 10 Reference Oil, 48 Sec. at 210° F., 110 V.I.	1.0	1.0	1.0
"5W" Oil, 40 Sec. at 210° F., 116 V.I.	1.15	2.0	1.45
SAE 20 Oil, 57 Sec. at 210° F., 108 V.I.	.9	.45	.7
SAE 30 Oil, 66 Sec. at 210° F., 108 V.I.	.8	.3	.6

TABLE 9

Road Tests on Oil Consumption

Effect of Viscosity Index:

	Consumption Ratio		
	Min. Difference	Max. Difference	Average Difference
SAE 10 Reference Oil, 48 Sec. at 210° F., 110 V.I.	1.0	1.0	1.0
SAE 10 Low V.I. Oil, 48 Sec. at 210° F., 16 V.I.	1.2	1.9	1.4

TABLE 10

Road Tests on Oil Consumption

Effect of Viscosity Index Improvers:

	Consumption Ratio		
	Min. Difference	Max. Difference	Average Difference
SAE 10 Reference Oil, 48 Sec. at 210° F., 110 V.I.	1.0	1.0	1.0
Reference Oil Plus V. I. Improver, 57 Sec. at 210° F., 132 V. I.	.9	1.1	1.0
Reference Oil Plus Bright Stock, 57 Sec. at 210° F., 108 V. I.	.9	.45	.7
"5W" Oil, 40 Sec. at 210° F., 116 V. I.	1.15	2.0	1.45
"5W" Oil Plus V. I. Improver, 48 Sec. at 210° F., 155 V. I.	1.1	2.1	1.4
"5W" Oil Plus Bright Stock, 48 Sec. at 210° F., 115 V. I.	1.1	1.8	1.3

Summary of Road Tests

Table 8 summarizes results of road tests on the effect of oil viscosity on consumption. Again there is quite a spread between maximum and minimum differences found in different vehicles, although the average ratios indicate a distinct decrease in consumption with increasing oil viscosity, and agree quite well with the laboratory engine test data as per Figure 3. Significantly, the over-all results of the road tests indicate a materially sharper change in oil consumption tendencies between the "5W" and SAE 10 oils, than between the SAE 10, 20 and 30 grades. This may be regarded as confirmation of the laboratory test data which indicate oil viscosities below the SAE 10 range are in the most critical region of the viscosity-consumption relationship.

Table 9 summarizes results of tests on the effect of V. I. on consumption. Although only one low V. I. oil was road tested, the results indicate definitely higher consumption tendency for the low V. I. oil compared to the 110 V. I. Reference oil. While the maximum differences on the road agree quite well with the laboratory engine values per Figure 4; the average road Consumption Ratio of 1.4 or 40 per cent higher than the Reference oil, is considerably less than the 1.9 ratio in the laboratory engine tests.

Improvers and Oil Consumption Tendencies

Table 10 summarizes the results of road tests to study the effect of V. I. improvers on oil consumption tendencies. These results are in good agreement with the laboratory engine tests and indicate again that V. I. improvers do not alter oil consumption appreciably from that characteristic of the petroleum base oil alone. In the case of the SAE 10 Reference oil, the addition of the V. I. improver to produce a large increase in viscosity at 210° and a very high V. I. effected no discernable change in consumption tendencies. Addition of petroleum bright stock to produce the same viscosity increase at 210°, but with a much lower V. I., resulted in a distinct improvement in consumption on the road.

In the case of the "5W" base oil, the high consumption is evidently due to the low viscosity and the "volatility" as necessitated by the low viscosity. Addition of either V. I. improver or petroleum bright stock did not effect any significant change or improvement in consumption tendencies. These results are in fairly good agreement with the laboratory tests per Table 3.

"Have Distinct Limitations"

The road test data are thus in substantial agreement with the laboratory engine tests in indicating that V. I. improvers have distinct limitations and dot not alter motor oil consumption characteristics to the extent which might be anticipated from customary V. I. and viscosity determinations. V. I. improvers must thus be regarded with due caution and must be evaluated on a much more extensive basis than the usual laboratory viscosity and V. I. determinations. Although V. I. improvers may be of benefit when used carefully and with due regard for their indicated limitations, they cannot be considered as substitutes or correctives for basic oil quality, or for natural viscosity, and V. I.

Conclusion

Road tests to evaluate motor oil consumption tendencies show quite wide variations in results in different vehicles due to the many variables in-

volved, and comparative tests in only a few cars may give apparent results which can be quite misleading. However, if sufficient vehicles are utilized, averages can indicate significant trends. On this basis, volatility, viscosity and V. I. are the three important physical properties affecting the consumption tendencies of motor oils. Oils having low volatility within defined limits, high viscosity and high V. I. tend to possess the lowest consumption characteristics.

With proper selection and control of operating conditions, laboratory engine tests for studying oil consumption tendencies yield results which correlate reasonably well with road performance.

Although this investigation of motor oil consumption characteristics has placed considerable emphasis on the limitations of V. I. improving additives, it is not intended to condemn V. I. improvers or their further study and development. It is hoped, however, that this work will stimulate more fundamental studies of the viscosity characteristics of polymer-mineral oil systems than are possible with simple Saybolt or glass tube kinematic viscosimeters. It is becoming more widely recognized that petroleum oils containing V. I. increasing polymers are Non-Newtonian fluids, and that viscosity and V. I. determinations made with conventional Saybolt or kinematic viscosimeters apply only at very low rates of shear and may be greatly misleading in terms of the very high shear rates developed in engines. Consequently, a broader and more complex problem of the viscosity-shear-temperature relation has been introduced by V. I. improvers, and a great deal more fundamental work is essential before their advantages and limitations can be adequately defined.

Appendix 1

Laboratory Engine Test Procedure For Evaluating Motor Oil Consumption Characteristics

MODEL H-2 LAUSON OIL TEST ENGINE:

Test Conditions:

Speed:	1840 rpm.
Load:	1.8 hp.
Air Fuel Ratio:	12:1 ± .5
Jacket Outlet Temperature	210°F. ± 2°
Jacket Inlet Temperature	200°F. ± 5°
Crankcase Oil Temperature	210°F. ± 2°
Crankcase Vacuum:	2 in. water
Initial Oil Fill:	1200 grams
Test Time:	20 hours

Procedure:

At the start of a test series, the engine is completely overhauled, and a new piston, rings and liner installed. Successive 20 hour runs are made on a Reference oil until the engine is run-in and consumption values level off to a uniform range. Alternate 20 hour tests are then made on selected test oils and Reference oil until the engine becomes sufficiently worn or altered that consumption values on the Reference oil become erratic. Usually from 20 to 30 runs of 20 hours each can be made before the engine requires overhaul.

Prior to each 20 hour test the engine is thoroughly flushed with the test oil, drained, and filled with the 1200 gram test charge. No oil make-up is added during the 20 hour test period. At the conclusion of the run, the oil charge is drained and reweighed to secure the consumption loss. All drainings are made with the crankcase oil at 200°-210° F., following a standardized procedure to maintain oil hold-up within the engine to a minimum and uniform quantity. Particular precaution is taken that oil losses by leakage through the crankcase breather, gaskets, crankshaft seals or governor shaft are negligible.

Appendix 2

Rotary, Thin Film Viscosimeter for Determining Relative Viscosities of Oils at High Rates of Shear

An unloaded, floating bearing is mounted on a shaft supported on pillow blocks and capable of being driven at speeds ranging from a few hundred up to several thousand rpm. The shaft is 1 inch in diameter and the floating bearing 1-inch in diameter by 2 inches long, with radial clearance held to .002 inch. (steel shaft, with babbitt lined bearings). The bearing is grooved to supply a uniform oil film, and a funnel shaped reservoir is attached at the top to hold the oil supply. The .002-inch clearance allows several cubic centimeters of oil to flow through the bearing during the course of a test determination.

A torque arm attached to the floating bearing and resting on a sensitive scale provides torque readings in gram—centimeters. The test unit is enclosed in a constant temperature housing, and oil film temperatures are held at 210° F. as measured by a thermocouple mounted at the surface of the babbitt.

The unit is calibrated by determining the torque readings for a series of straight petroleum oils of known viscosity at 210° F., and at each of the selected shaft speeds. A range of shaft speeds are selected to provide rates of shear from approximately 10,000 to 150,000 reciprocal seconds. Rates of shear are calculated from the bearing dimensions, shaft speed, and with an assumed uniform radial clearance of .002 inch.

The apparent viscosity at 210° F. of Non-Newtonian oils may then be estimated from their torque readings at each given rate of shear by reference to the viscosity—torque calibration curves of the straight petroleum oils.

This test device was not intended for highly accurate determination of oil viscosities at high rates of shear, but rather as a relatively simple means for exploring the complex relationship of viscosity and rate of shear which becomes involved with Non-Newtonian fluids.

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* * *

Simplified Multicomponent Distribution of Split

In II Parts

RAYMOND V. BAILEY

RAYMOND V. BAILEY

***THE APPLICATION** of Underwood's[7, 8, 9] equations and the Colburn[2] correlation for minimum reflux for the determination of the distribution of split keys at minimum reflux is presented. Equations have been developed to systematize the calculations and minimize the trial and error involved in the application of the Colburn correlation and Underwood's equations.*

A study has been made of the distribution of split keys which will give the optimum number of trays at reflux ratios other than total and minimum. The distribution of split keys obtained at total reflux was found to give a minimum number of trays at all reflux ratios except those very close to the minimum. At this point the optimum distribution approaches that obtained at minimum reflux.

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WITH multicomponent systems it is necessary to specify the maximum quantity of one component in the overhead and the maximum quantity of a second component in the bottoms. These specified components are known as the key components. The specified component with the highest volatility is designated the light key component and the other component is called the heavy key component. A heavy component is one which has a volatility less than the heavy key component and which appears in the fractionating pinch in negligible quantity. Similarly, a light component is one which has a volatility greater than that of the light key component and which appears in the stripping pinch in negligible quantity. A split key is defined as an unspecified component which appears in appreciable quantities in both pinches. Usually the relative volatility of a split key component is intermediate between that of the two specified components.

In order to determine the minimum reflux for a system containing split keys the distribution of these split keys in the overhead and bottoms must be determined. Underwood[7, 8, 9] has developed equations for the determination of minimum reflux for multicomponent systems and has demonstrated the application of these equations to systems containing split keys. The application is given here in slightly different form for purposes of comparison and to illustrate the use of Newton's[4] method to reduce the trial and error involved in the solution of the equations. An attempt is made to apply the equations to systems containing split keys in which the relative volatility is not constant. However, the accuracy of Underwood's equations depends on a choice of the feed tray temperature if the relative volatilities are not constant. In many cases the variation of the relative volatilities is sufficiently large that considerable doubt as to the true minimum reflux exists after the application of the Underwood equations due to the difficulty involved in selecting a good value for the feed tray temperature.

Colburn[2] presented an empirical correlation for minimum reflux which minimizes the doubt as to the proper temperatures to use. Colburn has stated that the distribution of the split key component at minimum reflux is such that the ratio of the mols of the split key component in the fractionating pinch to that in the stripping pinch lies between the corresponding ratios of the light key component and the heavy key component. However, for large values of Colburn's empirical term, ψ, there would be a considerable range of distributions of the split key component which would satisfy this criterium. In addition, a tremendous amount of trial and error is encountered in trying to satisfy Colburn's criteria as originally presented.

Bailey and Coates[1] have simplified the calculations required for Colburn's correlation for cases in which there are no split keys. Equations are presented in Part II for the application of Colburn's correlation to split keys.

Previously, the Fenske[3] equation for total reflux has been used to estimate the distribution of split keys for tray calculations for all reflux ratios between the minimum and total. No previous study has been made in an attempt to determine the distribution of split keys which would give an optimum number of trays for a given reflux ratio and separation of the key components.

Fractionation Calculations

Key Components

Part I

and JESSE COATES

JESSE COATES

NOMENCLATURE

c — Correction factor
d — Mols of a component in the overhead
D — Total mols of overhead
K — Equilibrium constant
l — Mols of a component in the liquid phase
L — Total mols of liquid downflow in tower
M — Mols of a component (liquid plus vapor)
m — Pseudo ratio of liquid to vapor
q — Heat required to convert one mole of the feed to saturated vapor divided by the latent heat of the feed
R — Mols of reflux per mol of overhead
r — Ratio of mols of light key component to heavy key component
S — Number of equilibrium steps
V — Total mols of vapor upflow in tower
w — Mols of a component appearing in the bottoms
X — Mol fraction of a component in the liquid phase
Z — Total mol fraction of a component (liquid plus vapor)
α — Relative volatility of a component with respect to the heavy key component
ψ — Empirical factor defined by equation (11a)
ϕ — Defined by equation (1) and has a value between the relative volatilities of the key components

Subscripts:

av — Average
D — Overhead
F — Feed
f — Feed tray
h — Heavy component (volatility less than that of the heavy key component)
hK — Heavy key component
l — Light component (volatility greater than that of the light key component)
L — Liquid in feed
lK — Light key component
m — Stripping section
M — Minimum
n — Fractionating section
s — Split key component
T — Top of tower
V — Vapor in the feed

Superscripts:

′ — Denotes uncorrected values

Application of Underwood's Equations for the Distribution of Split Keys at Minimum Reflux

Underwood has derived the following equations for the determination of minimum reflux ratio:

$$\sum \frac{\alpha Z_F}{\alpha - \phi} = 1 - q \qquad (1)$$

$$\sum \frac{\alpha X_D}{\alpha - \phi} = R_M + 1 \qquad (2)$$

where α — relative volatility of a component with respect to the heavy key component.
X — mol fraction of a component in the liquid phase.
Z — total mol fraction of a component (liquid plus vapor).
q — heat required to convert one mole of feed to saturated vapor divided by the latent heat of the feed.
R — mols of reflux per mol of overhead.
ϕ — defined by equation (1) and the value of ϕ lies between the relative volatilities of the key components.

Subscripts:
D — overhead
F — feed
M — minimum

Since the distribution of the split key is unknown, it is more convenient to define the system by stating the mols of the light key component appearing in the overhead and the mols of the heavy key component appearing in the bottoms rather than specifying the mol fractions, respectively.

Rewriting equation (1) and (2) in terms of mols

$$\sum \frac{\alpha M_F}{\alpha - \phi} - M_v = 0 \qquad (3)$$

$$\sum \frac{\alpha d}{\alpha - \phi} = (R_M + 1)(D) = V_n \qquad (4)$$

Where M_F — mols of a component in the feed.
M_V — mols of vapor in the feed
d — mols of a component in the overhead.
D — total mols of overhead.

V_n — total mols of vapor upflow in the fractionating section of the tower.

If N split keys are present in the feed then there are N plus one values of ϕ which lie between the relative volatilities of the key components that will satisfy equation (3) By substituting these N plus one values of ϕ in equation (4) there are obtained N plus one equations which on simultation yield the distributions of each split key and the minimum reflux.

In order to facilitate the solutions of equation (3) it is proposed that Newton's[4] method for irrational roots be used.

$$\phi_2 = \phi_1 - \frac{f(\phi_1)}{f'(\phi_1)} \qquad (5)$$

Where ϕ_1 — first assumption of ϕ .

ϕ_2 — second approximation of ϕ .

$$f(\phi_1) = \sum \frac{\alpha M_P}{\alpha - \phi_1} - M_v$$

$$f'(\phi_1) = \sum \frac{\alpha M_P}{(\alpha - \phi_1)^2}$$

Procedure for Constant Volatility:

The procedure for application of Underwood's equations to systems containing split keys and constant volatility is as follows:

1) Assume a value of ϕ between the relative volatilities of the light key component and the split key component.
2) Correct this assumption by means of equation (5) until equation (3) is satisfied.
3) Repeat steps (1) and (2) for a value of ϕ between the relative volatilities of the heavy key component and the split key component.
4) Substitute the values of ϕ obtained into equation (4) and simultate to obtain the distribution of the split key and the minimum reflux.

Quite often, from observation of the system, a fair choice of ϕ_1 can be made which will give $\phi_2 = \phi$ for most purposes.

Varying Relative Volatility:

The proper temperature for the evaluation of relative volatilities is the feed tray temperature. For the case in which light and heavy components are absent this temperature is readily determined from the thermal condition of the feed. However, if light and/or heavy components are present the temperature of the feed tray is not readily obtainable and the use of arithmetic averages of the relative volatilities taken at the pinch temperatures is recommended. These temperatures are obtained at the expense of further trial and error. If the variation of the relative volatility is appreciable the equations of Underwood appear to be unreliable. For this case, the use of the Colburn correlation, as presented in Part II, is recommended.

Recommended Procedure for Varying Relative Volatility:

The recommended procedure for the application of Underwood's equations to systems containing split keys and varying relative volatility is as follows:

1) Assume a reasonabe minimum reflux and distribution of the split key.
2) Determine the approximate temperatures of the pinches by use of equations (7b) and (8b) which appear in Part II of this article.
3) Evaluate the arithmetic average relative volatilities from the relative volatilities obtained at these pinch temperatures.
4) Proceed as for constant volatility using these average relative volatilities.
5) If the minimum reflux ratio and distribution of the split key differs appreciably from the assumed values just obtained to start the new set of calculations.

The following examples have been selected to illustrate the application of Underwood's equations for constant relative volatility and for varying relative volatility.

Illustrative Example I

Application of Underwood's equations to a system with constant relative volatility:

Component	α	Mols Feed	d	w
A	4	15	15	.....
B	2	15	15	trace
C	1.7	20	d_C	w_C
D	1.3	20	d_D	w_D
E	1.0	15	trace	15
F	0.5	15	.....	15
		100		

Feed is saturated vapor. Components C and D are split keys.

	αM_P	$\frac{\alpha M_P}{\alpha-\phi}$ $\phi=1.9$	$\frac{\alpha M_P}{\alpha-\phi}$	$\frac{\alpha M_P}{(\alpha-\phi)^2}$	$\frac{\alpha M_P}{\alpha-\phi}$ $\phi=1.9018$	$\frac{\alpha M_P}{\alpha-\phi}$	$\frac{\alpha d}{\alpha-\phi}$
A	60	2.1	28.6	13.6	2.098	28.6	28.6
B	30	0.1	300.	3000.	.0987	305.5	305.5
C	34	−0.2	−170.	850.	−.2018	−168.7	−8.43 d_C
D	26	−0.6	− 43.3	72.2	−.602	− 43.2	−2.16 d_D
E	15	−0.9	− 16.7	18.5	−.902	− 16.7	.....
F	7.5	−1.4	− 5.35	3.8	−1.402	− 5.4	.....
			93.2	3958.1		100.1	V_n

$\phi = 1.9 - (93.2 - 100)/3958.1 = 1.9018$

	αM_P	$\frac{\alpha M_P}{\alpha-\phi}$ $\phi=1.5$	$\frac{\alpha M_P}{\alpha-\phi}$	$\frac{\alpha M_P}{(\alpha-\phi)^2}$	$\frac{\alpha M_P}{\alpha-\phi}$ $\phi=1.508$	$\frac{\alpha M_P}{\alpha-\phi}$	$\frac{\alpha d}{\alpha-\phi}$
A	60	2.5	24	9.6	2.492	24.0	24.0
B	30	0.5	60	120.	.492	61.0	61.0
C	34	0.2	170	850.	.192	177.0	8.85 d_C
D	26	−0.2	−130	650.	−.208	−125.0	−6.25 d_D
E	15	−0.5	− 30	60.	−.508	− 29.5	.....
F	7.5	−1.0	− 7.5	7.5	−1.08	− 6.9	.....
			86.5	1697.1		100.0	V_n

$\phi = 1.5 - (86.5 - 100)/1697.1 = 1.508$

	$\frac{\alpha M_P}{\alpha-\phi}$ $\phi=1.1$	$\frac{\alpha M_P}{\alpha-\phi}$	$\frac{\alpha M_P}{(\alpha-\phi)^2}$	$\frac{\alpha M_P}{\alpha-\phi}$ $\phi=1.11$	$\frac{\alpha M_P}{\alpha-\phi}$	$\frac{\alpha d}{\alpha-\phi}$
A	2.9	20.7	7.1	2.89	20.8	20.8
B	.9	33.3	37.0	.89	33.7	33.7
C	.6	56.6	94.5	.59	57.6	2.88 d_C
D	.2	136.0	650.	.19	136.9	6.84 d_D
E	−.1	−150.0	1500.	−.11	−136.2	.....
F	−.6	− 12.5	20.8	−.61	− 12.3	.....
		78.1	2309.4		100.5	V_n

$\phi = 1.1 - (78.1 - 100)/2309.4 = 1.11$.

Equating V_n's

$$28.6 + 305.5 - 8.43\ d_C - 2.16\ d_D = 24.0 + 61.0 + 8.85\ d_C - 6.25\ d_D$$

$$24.0 + 61.0 + 8.85\ d_C - 6.25\ d_D = 20.8 + 33.7 + 2.88\ d_C + 6.84\ d_D$$

From which $d_C = 16.81$; $d_D = 10.0$

$$R_M = \frac{28.6 + 305.5 - (8.43)(16.81) - (2.16)(10.0)}{15 + 15 + 16.81 + 10.0} - 1$$

$$= 3.00 - 1 = 2.00$$

Illustrative Example II

Application of Underwood's equations when relative volatility is not constant.

	M_F	d	w
C_1	3	3.0	....
C_2	7	7.0	....
C_3	15	14.7	0.3
C_4	33	*13.0	*20.0
C_5	30	0.2	29.8
C_6	12	....	12.0
		37.9	62.1

* Assumed distribution.

$q = .69$

Tower pressure = 200 psia. Equilibrium data from nomograph by Scheibel.[4] C_4 is the split key.

Assume $R_M = .75$

Then $L_n = (.75)(37.9) = 28.4$ $\quad L_m = 28.4 + 69 = 97.4$

$V_n = (1.75)(37.9) = 66.3$ $\quad V_m = 66.3 - 31 = 35.3$

$K_{hk_n} = (L/V)_n = .428$ $\quad$ Temp. = 196° F.

$K_{1k_m} = (L/V)_m = 2.76$ $\quad$ Temp. = 237° F.

	K^{196}	α^{196}	K^{237}	α^{237}	α_{av}
C_1	21.0	49.0	24.5	37.7	43.4
C_2	5.42	12.68	6.85	10.52	11.6
C_3	2.16	5.05	2.76	4.25	4.65
C_4	.948	2.22	1.30	2.00	2.11
C_5	.428	1.00	.65	1.00	1.00
C_6	.20	.47	.329	.51	.49

	$\phi = 1.345$ / $\alpha - \phi$	αM_F / $\alpha - \phi$	αM_F / $(\alpha - \phi)^2$	$\alpha = 1.350$ / $\alpha - \phi$	αd / $\alpha - \phi$
C_1	42.05	3.09	0.1	42.05	3.09
C_2	10.25	7.92	0.8	10.25	7.92
C_3	3.305	21.05	6.4	3.30	20.7
C_4	.765	90.7	116.8	.76	$2.78\ d_{C_4}$
C_5	— .345	— 86.95	252.	—.35	—.57
C_6	— .855	— 6.87	8.0	—.86	.....
		29.14	386.1	M	V_n

$\phi = 1.345 - (29.14 - 31)/386.1 = 1.350.$

Equating V_n's and solving $d_{C_4} = 13.3$

Substituting in equation (4) $R_M = .787$

NOTE: If results had differed very much from assumptions, it would have been necessary to obtain a new set of average relative volatilities and repeat the calculations.

The application of Underwood's[7, 8, 9] equations for obtaining the distribution of split keys at minimum reflux has been presented. It has been pointed out that one difficulty in the use of these equations lies in the selection of a proper temperature for the evaluation of relative volatilities. For this reason, these equations are unreliable for systems in which the relative volatilities of the various components varies appreciably with temperature. Therefore, equations are developed in the next article for a systematic application of Colburn's[2] correlation for the distribution of split key components at minimum reflux.

In the next article the distribution of split keys at reflux ratios other than the minimum and total reflux will also be discussed.

	M_F	α_{av}	αM_F	$\phi = 3.8$ / $\alpha - \phi$	αM_F / $\alpha - \phi$	αM_F / $(\alpha - \phi)^2$	$\phi = 3.712$ / $\alpha - \phi$	αM_F / $\alpha - \phi$
C_1	3	43.4	130.	39.6	3.28	.1	39.688	3.28
C_2	7	11.6	81.2	7.8	10.4	1.3	7.888	10.3
C_3	15	4.65	69.7	.85	82.0	96.5	.938	74.4
C_4	33	2.11	69.5	—1.69	—41.1	24.3	—1.602	— 43.3
C_5	30	1.00	30.0	—2.8	—10.71	3.8	—2.712	— 11.05
C_6	12	.49	5.88	—3.31	— 1.78	.5	—3.222	— 1.82
					42.09	126.5		31.81

$\phi = 3.8 - (42.09 - 31)/126.5 = 3.712.$

	αM_F / $(\alpha - \phi)^2$	$\phi = 3.705$ / $\alpha - \phi$	αd / $\alpha - \phi$	$\phi = 1.3$ / $\alpha - \phi$	αM_F / $\alpha - \phi$	αM_F / $(\alpha - \phi)^2$
C_1	0.1	39.695	3.28	42.1	3.09	0.1
C_2	1.3	7.895	10.3	10.3	7.88	0.8
C_3	79.2	.945	72.3	3.35	20.8	6.2
C_4	27.0	—1.595	$-1.322\ d_{C_4}$	.81	65.8	106.
C_5	4.1	—2.705	— .07	— .30	—100.	333.3
C_6	.5	—3.215	.....	— .81	— 7.25	9.0
	112.2		V_n		10.32	455.4

$\phi_n' = 3.712 - (31.81 - 31)/112.2 = 3.705.$

$\phi_n = 1.3 \quad -(10.32 - 31)/455.4 = 1.345.$

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(End of Part I. Part II will appear in the February number)

* * *

SIMPLICITY of design and low initial investment cost are claimed for "Houdriflow," an improved moving-bed catalytic cracking process recently announced by Houdry Process Corporation. The new process, according to the company's engineering staff which prepared the accompanying article, is said to differ from the Houdry's Thermofor catalytic cracing process in four important respects: 1) method of transporting catalyst, 2) range of catalyst circulation rates available, 3) simplification of regenerator, and 4) physical arrangement of principal vessels.

Simplicity of Process and Low Investment Cost Stressed

IMPROVED MOVING-BED CATALYTIC CRACKING PROCESS DESCRIBED BY STAFF OF HOUDRY PROCESS CORPORATION

HOUDRY Process Corporation's improved moving-bed catalytic cracking process, called "Houdriflow," retains the many desirable features of the Thermofor catalytic cracking (TCC) process, which has been licensed by the Houdry Company since 1941, but it differs from the TCC design in four major respects:

1) Method of transporting catalyst.

2) Range of catalyst circulation rates available.

3) Simplification of regenerator.

4) Physical arrangement of principal vessels.

Chief Features of Process

The new process also is characterized by simplicity of design and low initial investment cost.

Distinct advantages are derived from the four basically new features of the Houdriflow design.

1) *A flue gas lift* transports pelleted or bead catalyst from the bottom to the top of the unit replacing the bucket-type elevator of the conventional TCC process. The feasibility of lifting pelleted catalyst with air or flue gas has been fully demonstrated by extensive work on pilot and commercial scale apparatus. The utilization of the lift a) removes the practical limitation on catalyst circulation rate presently imposed by bucket-type elevators, making available a wide range of circulation rates, and b) simplifies the means of transporting catalyst, eliminating mechanical devices.

2) *Catalyst-to-oil ratios* in the range of 4 to 8 are provided whereas conventional TCC units operate with catalyst-to-oil ratios in the range of 2 to 3 due to elevator capacity limitations. This range of catalyst-to-oil ratios permits operation with stocks from zero to 100 percent vaporized and a reduction in the amount of reactor feed preparation equipment since a major portion of the reaction heat is supplied by the catalyst entering the reactor.

3) *A simplified regenerator* is made possible by the higher catalyst circulation rates. Since a major portion of the regeneration heat is absorbed by the flowing catalyst, one or two burning zones are sufficient; whereas, conventional TCC units use seven to ten. No sacrifice of flexibility in regenerator operation is entailed by these modifications.

4) *A superimposed, self-supporting, circular reactor and regenerator section* is the fourth distinguishing feature. This arrangement of the principal vessels a) makes it necessary to lift the catalyst only once to complete a cycle of flow through the system and b) results in a smaller ground area requirement for the installation of a unit of a given capacity.

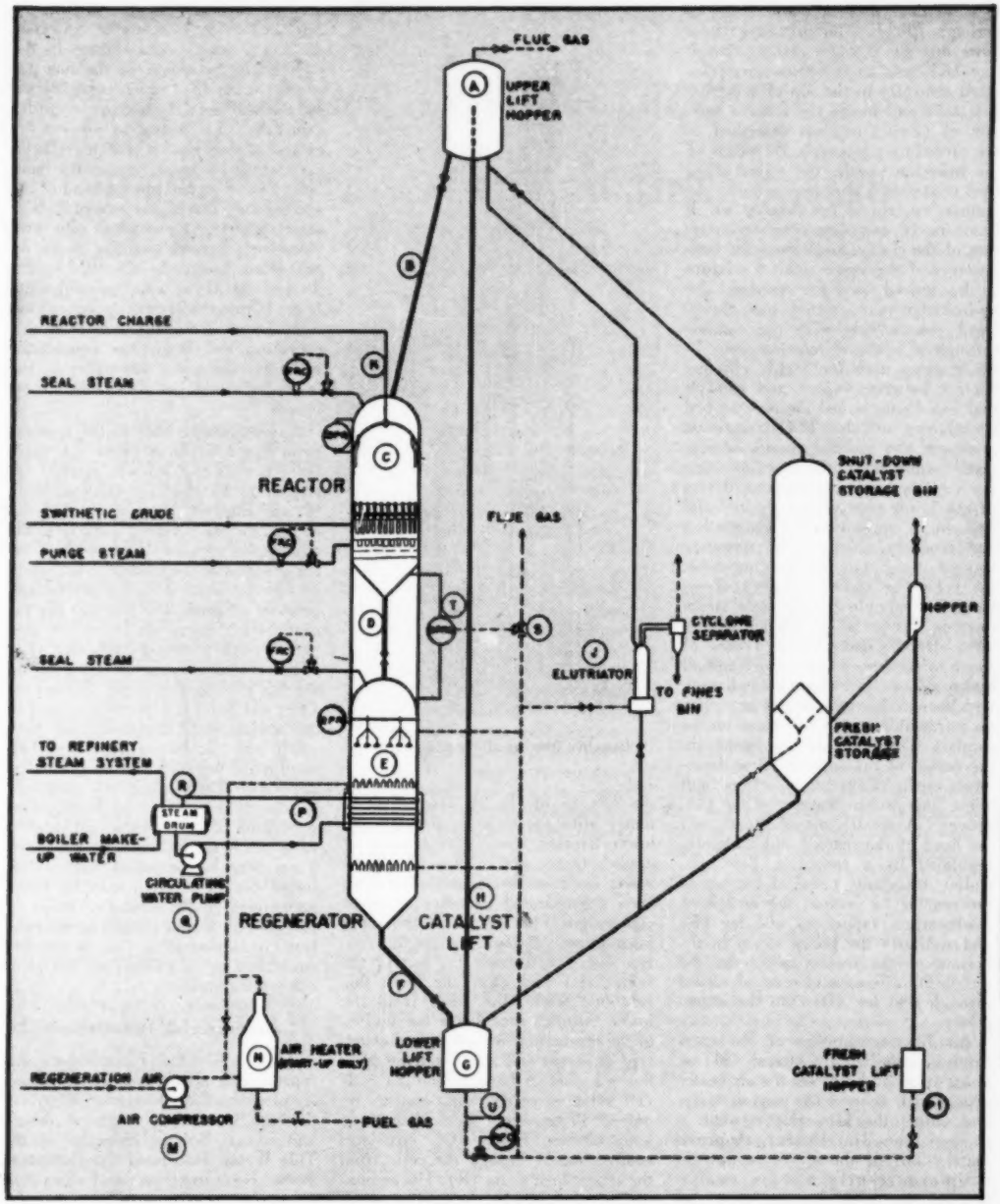
Due to the simplifications in the regenerator, the means of transporting catalyst, and the physical arrangement of equipment, the initial capital investment for a Houdriflow unit is approximately 80 percent of that of a conventional TCC unit of the same capacity. Moreover, Houdriflow provides even greater flexibility than conventional TCC with respect to reactor operating conditions and the type of charging stock that may be processed. Additional economies can be foreseen for Houdriflow in that direct operating costs as well as maintenance costs will be materially reduced. The economic advantages of Houdriflow over the conventional TCC is shown by the following table. (The comparison was made of units of 5000 barrels-per-stream-daily capacity and figures are dollars per day.)

Utilities, savings	$260
Catalyst, savings	—42
Maintenance, savings	39
Amortization, savings	217
Total savings	$474

These advantages stem from the simplification in design. For example, a lower fuel requirement for reactor feed preparation accounts for a significant reduction in operating costs. Likewise, it is evident that the new kiln with a minimum of internal structural elements will require even less maintenance than a TCC kiln.

Description of Process

In order to trace the principal flows through a Houdriflow unit reference is made to the accompanying flow diagram, Figure 1 Regenerated pelleted or head catalyst in the upper lift hopper (A) flows by gravity through the reactor seal leg (B) into the catalyst distributing head of reactor (C). From this point the catalyst enters the reaction zone via two paths: an annular orifice located in the center of the top seal plate permits approximately 80 percent of the catalyst to enter the reaction zone in the form of an annular curtain which surrounds the mixed-phase reactor charge injection nozzle; the balance of the catalyst flows through a number of peripheral catalyst feed pipes, the length of which determines the height of the bed of catalyst in the reactor. Continuing to flow by gravity, the catalyst passes downward through the reaction zone, through vapor disengaging and steam purging sections in the bottom of the reactor and then by way of seal leg (D) into the distributing head of kiln (E). The spent catalyst then flows into the kiln proper through a distributor especially designed to insure uniform distribution and continues downward through two solid-bed regeneration zones. Leaving the bottom of the kiln, the catalyst flows by gravity through seal leg (F) into the lower lift hopper (G) from which point it is transported by means of flue gas from the kiln through the vertical lift pipe into upper lift hopper (A) to complete a



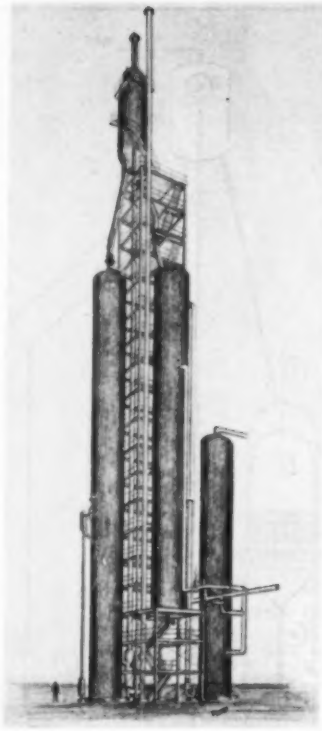
Flow Diagram Houdriflow Catalytic Cracking Process

cycle of flow. As in the conventional TCC process, a small stream of catalyst from hopper (A) is continuously by-passed to the elutriator (J) where "fines" are removed by air classification to maintain the average particle size of the catalyst in the system at the desired value.

The oil charging stock may be delivered to the Houdriflow reactor in the liquid phase, in a partly vaporized state or in a completely vaporized state. The more general case of partly vaporized or mixed-phase feed is assumed for this description. In this instance any feed stock suitable for catalytic processing is preheated by head exchange and a fired preheater

to a nominal preheat temperature of perhaps 700° F. The mixture then flows directly through reactor charge line (K) into an injection nozzle located centrally in the top of the reaction zone and inside the annular curtain of flowing catalyst described in the preceding paragraph. By means of the injection nozzle, the mixed-phase feed is atomized and directed onto the annular curtain of hot catalyst which immediately completes the vaporization of the charge and brings the temperature of the vapor-catalyst mixture to the desired level for reaction. The hydrocarbon vapors then pass downward concurrently with the catalyst through a solid-bed reaction zone. In the reaction zone the highly efficient contact between vapors and catalyst that has distinguished the moving bed technique of the TCC process is achieved. The cracked vapors or synthetic crude leave the reaction zone via a catalyst-vapor disengager device in the lower part of the reactor and flow to a conventional fractionation and recovery plant. After passing through the vapor disengaging zone, the coked or spent catalyst flows through a simple but efficient steam purging section before leaving the reactor. By the countercurrent flow of steam to catalyst, stripping of residual hydrocarbons is achieved and even with the heaviest reactor charge stocks, no extractable material remains on the catalyst. There are no innovations in the design of the vapor-catalyst disengager or the steam purge section, both being time-proven features of the TCC process. A small flow of steam into the head of the reactor, automatically regulated by a recording flow controller, maintains a seal at the top of the reactor to prevent the escape of hydrocarbon vapors up seal leg (B) and similarly the purge steam in the bottom of the reactor precludes the possibility of escape of cracked vapors through seal leg (D) into the regenerator.

Air for regeneration of the spent catalyst, supplied by blower (M) at about 10 psig., by-passes the air heater (N), which is used for start-up only, and enters the kiln (E) through a channel-type distributor. Approximately half of the air flows upward countercurrently to the catalyst through the upper burning zone and



Isometric Drawing of Houdriflow Unit

the balance of the air flows concurrently with the catalyst through the lower burning zone. This description applies to the design shown. Several minor variations are possible and have been incorporated in other commercial designs. Flue gases from the upper burning zone disengage above the catalyst distributor, leave the top of the regenerator and enter the main flue gas duct while flue gases from the lower burning zone leave the bottom of the regenerator by way of a channel-type collector and also enter the main flue gas duct. A bank of cooling coils (P) removes regeneration heat as required to maintain desired catalyst temperatures. Pump (Q) circulates cooling water through the coils from the steam flash drum (R). The amount of heat absorbed by the cooling water may be regulated by the number of coils in service. Pressure in the range of 5 to 9 psig. is maintained in the regenerator by means of the flue gas control valve (S), which is positioned by the differential pressure recorder controller (T). A seal to prevent the escape of flue gas up seal leg (D) is maintained by an automatically regulated flow of steam into the head of the regenerator. The higher rate of flow of catalyst in the Houdriflow kiln provides for a greater quantity of the regeneration heat to be absorbed by the flowing catalyst and, consequently, fewer burning, and cooling sections are needed than in the TCC kiln. With this exception, the Houdriflow regenerator embodies the same principles as the improved design of TCC kiln in use today.

Approximately half of the flue gas from the kiln flows from the main flue gas duct to the lower catalyst lift hopper to be used for transportation for the catalyst. Most of the balance of the flue gas is vented directly to the atmosphere, a small portion of it being diverted to the elutriator for pneumatic classification of the catalyst and removal of fines. The flue gas for the catalyst lift enters the lower lift hopper through pressure controller (U), engages and carries the catalyst up the lift pipe to the upper lift hopper (A), and from this point is vented to the atmosphere. Experience on both small and commercial-scale gas lifts employing pelleted and bead catalyst has shown that catalyst flow rates may be closely controlled by appropriate regulation of the flue gas and catalyst velocities in the lift pipe. Furthermore, it has been demonstrated that catalyst losses due to attrition may be easily maintained in the attractive range of 0.01 to 0.02 weight percent of the catalyst circulation rate. This is roughly equivalent to 0.2 pounds per barrel of reactor throughout.

Commercial Installations

At this writing Houdriflow units representing a total processing capacity of about 40,000 barrels per stream day are in various stages of design and construction in refineries of the Tide Water Associated Oil Company, Peico Corporation and Sun Oil Company.

* * *

Crude Oil Metering

INSTRUMENTATION FOR OIL LINES CALLED "NEW FIELD OF UNLIMITED POSSIBILITIES"

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ALL history, from the earliest records of civilized groups, has shown that measurement has played an essential part in the material relationships of mankind. Many centuries before the Christian era, man had devised methods of measurement and had established remarkably accurate standards for such socially important quantities as time, length, volume, and weight. With the development of our complex modern world such measurements have increased in diversity and complexity to the point where they are now universal and indispensable. The truth of this statement is apparent when we consider that every product is measured many times, and for many characteristics, before it reaches the ultimate consumer. Measurements are, therefore, an integral part of the complicated social relationships of modern man.

Measurements have made another, and perhaps a more significant, contribution to modern civilization which has developed largely through the continued progress in the understanding of physical law. Science, as we see it, is dependent primarily on the quantitative knowledge of those laws which is obtained by measurement. Electricity, for example, is perceived by the human senses only through its effects; and all precise knowledge on which the electrical industry is based exists because these effects have been accurately measured. Similarly, the developments in chemistry, medicine, and our own oil industry have been made possible through knowledge gained through measurement. It follows also that, if mankind is to progress through science and technology, its store of knowledge must continue to expand through advantages in the art of measurement.

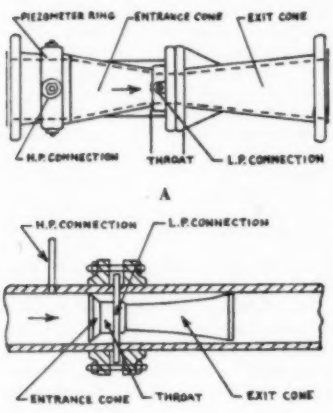


FIGURE 1

DESCRIBED here is the metering of crude oil by orifice meters, variable-area orifices, venturis, and positive-displacement meters. It is not the author's intent either to recommend or justify the use, or application of any one type, or make of flow meter. Rather, it is the purpose—and justifiably the hope—that this report "may serve as an impartial analysis of the problems of flow-meter installation with relation to pipe-line application."

Presentation was to a Division of Transportation pipe-line symposium, in Chicago, during the annual meeting of the American Petroleum Institute, November 8, 1948. Certain revisions have since been made.

"Unlimited Possibilities"

Instrumentation, in general, in the pipe-line industry is a new field of unlimited possibilities. However, for a number of years oil has been metered for one or more of the following reasons:

1) Checking of receipts from gathering lines, gathering stations, and between main-line relay stations.

2) To replace of tanks at field stations.

3) For measuring deliveries.

4) Blending various grades of crude and crude-oil products.

5) To determine whether a drop in line pressure is due to a line break or a faulty pump.

6) Indicating the arrival of a different batch.

The term "flow meter" as used in this paper applies to an instrument used to meter a quantity of fluid flowing in a closed conduit and the various types of flow meters, their installation, and operation will be discussed.

I. Differential Flow Meter

The most commonly known meter in use today is the orifice or head meter. By virtue of its versatility, this meter is adaptable to many uses on the pipe-line system. However, it has its limitations. The operation of the differential flow meter is based on the relation between the rate of flow of the fluid, and the pressure loss in flowing through a restriction in the flow line.

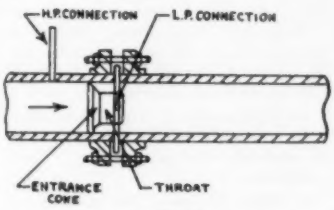
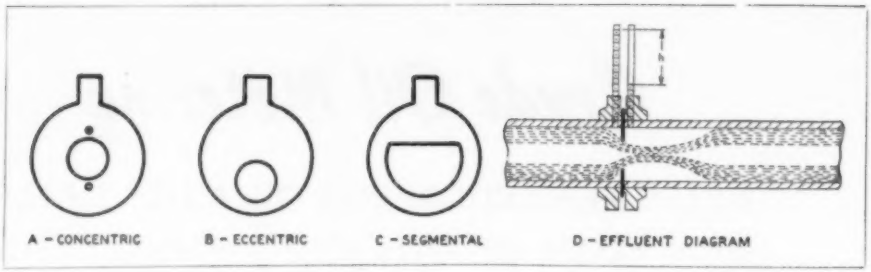


FIGURE 2

FIGURE 3



This relation simply stated is: the pressure loss caused by the restriction is proportional to the square of the velocity of the fluid. The restriction may be either of three devices, as follows:

1) **A venturi tube or an insert venturi tube** (Figure 1-A): The venturi tube is a flow device which is inserted into a pipe line in much the same manner as a section of pipe, but it has a small diameter mid-section which is termed a throat. The venturi consists of a main barrel section of a diameter identical or closely corresponding to the internal diameter of the pipe to which it is connected. The barrel leads into a cone of fixed angular convergence. This cone then connects through a throat section, accurately machined to calculated dimensions and of a smaller diameter than the barrel. The throat connects to an exit cone of fixed angular divergents, terminating at a diameter corresponding to the original pipe size.

Installation Cost Is High

The barrel is equipped with piezometer connections in an annular pressure ring, for averaging the upstream pressure. The high-pressure meter connection is made here. The throat is similarly designed, and the low-pressure meter connection is made in it. The difference in the pressure between the barrel and the throat produces the differential head for fluid metering. However, in a pipe line through which scrapers have to be passed, the venturi must of necessity be installed in a bypass. This factor alone makes the cost of a venturi-tube installation on a large-diameter line almost prohibitive. The high intitial cost of installation and the high replacement cost of a venturi tube are factors against its use. However, despite its high installation cost, the venturi advantages are:

a) *High accuracy:* The venturi tube, when carefully made and calibrated, is probably the most accurate unit available.

b) *High efficiency:* The pressure recovery of the venturi tube is greater than in any other primary element, and should be used when this is important.

c) *Accuracy:* With high ratios of orifice diameter to pipe diameter, the venturi tube will give an accurate reading and should be used when high ratios are necessary.

d) *Resistance to abrasion:* The venturi tube has smooth curves, and it resists wear effectively.

e) *Does not catch dirt or sediment:* As the tube is smooth, there is no obstruction to catch foreign material which would introduce a source of error.

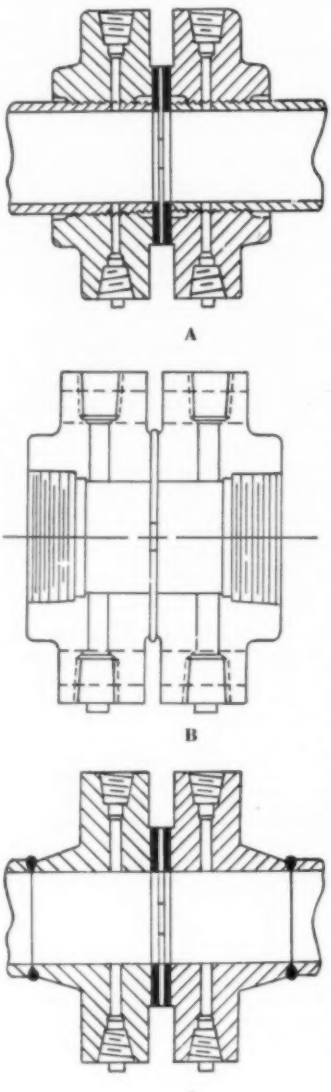


FIGURE 4

The insert venturi tube (Figure 1-B) is an adaptation of the regular venturi tube. It retains the desirable characteristics of the standard tube, with certain added advantages for special conditions such as where it is necessary to measure flow under extremely high-pressure conditions. The insert tube avoids an expensive construction of the classic venturi tube under these conditions.

This primary element is inserted within the pipe line, and is held in position between two companion flanges by means of a dutchman made integral with the tube. The low-pressure meter connection is located in the dutchman, which houses the piezometer openings and the throat pressure belt. The pressure-meter connection is directly tapped in the wall of the pipe approximately one pipe diameter upstream from the entrance cone. The insert tube is constructed with an upstream transition section, an accurately measured throat, and a recovery cone designed to recover the flow with a minimum loss of pressure head.

2) **Flow nozzle** (Figure 2): This too must be installed on a bypass where scrapers must be run. Its cost is not as great as a venturi tube, but is greater than an orifice plate. Great care must be exercised in the installation of a flow nozzle in order that the pressure taps are installed at points designated by the manufacturer. The location of these taps is critical. The

advantages of the flow nozzle are:

a) *Good efficiency:* The pressure recovery is considerably less than that for the venturi tube, but greater than the orifice plate.

b) *Accuracy*, with high ratios of orifice to pipe size: The flow nozzle will operate on $\frac{d}{D}$ ratios greater than 0.75.

c) *Good resistance to wear* because of its long smooth curves.

d) Offers a *greater pressure differential* to actuate the recording instrument.

3) **The orifice plate** (Figure 3): The thin edge orifice plate is by far the most widely used type of primary element for differential pressure meters. The orifice plate is the more predominately used primary measuring device because of its simplicity, low cost of manufacture, and ease of installation. *Bulletin 89 of The Ohio State University Engineering Experimental Station*, referring to tests conducted on commercial orifice plates, has this to say: "In general, these tests were conducted on commercial orifices installed in sections of commercial pipe and the results, therefore, should apply to any orifice installation, provided care is taken properly to construct the orifice and to choose clean and smooth pipe. It seems clear, after five years' experimentation in the calibration of fluid meters of various sorts, that the orifice meter is the more easily reproduced and the cheapest type of differential head meter and, if properly used with correct coefficients, is as accurate as any other type meter. For this reason it is, therefore, the best type of primary element to use."

The conventional orifice plate consists of a thin sheet of metal with a round concentric opening. The thickness of the plate is governed by the tensile strength required to prevent buckling under ordinary differential pressure. In general pipe-line work a ⅛-inch plate is used in pipe sizes to 16 inches, and ¼-inch plates in pipe sizes over 16 inches.

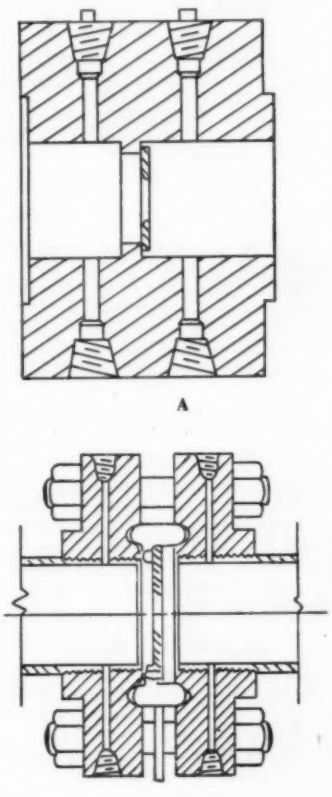
The upstream edge of orifice plates must be square, clean, and sharp if consistent results are to be obtained. The upstream face of the plate must be flat and perpendicular to the axis of the pipe when in position. Thickness of the orifice edge should not exceed ⅛ inch, and, for orifice plates with openings less than ½ inch in diameter, the edge thickness should not be greater than one-sixteenth inch. If, to secure this, beveling of the edge is necessary, the plate should be cut away on the downstream face at an angle not less than 45 degrees.

Any fluid, in passing through a square sharp-edge opening, has a flow contour similar to that shown in Figure 3-D. The effluent stream is reduced in diameter to something less than the diameter of the orifice. The smallest diameter of the stream is the *vena contracta* which corresponds to the throat diameter of the venturi or flow nozzle.

Two Other Types

There are, in addition to the concentric plates, two other types of orifice designs: mainly, a) eccentric type, i.e. the orifice is offset; b) segmental type, i.e., a segmental shaped orifice.

Eccentric and segmental plates are useful and desirable when the measured fluid carries suspended matter which might tend to build up back of a concentric orifice plate, causing erratic readings. The plate is installed so that the orifice is within 0.025 inch of the bottom of the pipe, thereby reducing clogging to a minimum. These plates are also used when it is desirable to relocate the downstream tap for installation convenience, which is occasionally required where flanges have long hubs. Concentric factors do not apply when eccentric and segmental plates are calculated.



A

B

FIGURE 5

There are several methods utilized in the mounting of an orifice plate, and in locating the pressure taps.

Propably the most commonly used method is the flange mounting (Figure 4).

The AGA standard mounting (Figure 4-A) uses a fully tapped flange, i.e., the flange is tapped through the full length of the hub. The pipe is screwed up until it is flush with the face of the flange. After the flange and pipe are assembled, the flange and pipe are drilled.

Another type of threaded flange is shown in Figure 4-B. The flange is tapped prior to assembly, and thus eliminates the drilling.

The welding-neck flange is shown in Figure 4-C. Where welding is the accepted practice, this is an ideal flange, although the initial cost is higher.

Figure 5-A shows the filler-block mounting with flanges. This is used in high-pressure work. Its cost is high, and it is very heavy in weight.

The easiest high-pressure mounting, using flanges, is to use a holding ring with ring-joint flanges. This is shown in Figure 5-B. One precaution that must be observed in the use of this type of installation is that gaskets, of any type, should never be re-used.

The adjustable orifice fitting is widely used in pipe-line work. One type is pictured in Figure 6. These fittings look like a flanged gate valve, and are installed in the same manner as a gate valve. They are designed to permit the changing of orifice plates without interrupting the flow. The plate can also be raised to permit the passing of a scraper.

Other than flange taps, some companies use other methods to obtain the differential pressure. Three methods are pictured in Figure 7.

Corner taps are most commonly used abroad; however, of late, they are also being used to some extent here. Research has shown that they are not much better than pipe taps.

Vena contracta taps are used to obtain the maximum differential across the orifice plate. The location of these taps is variable, dependent on the line size and the orifice to pipe ratio $\frac{d}{D}$.

Pipe taps are always connected 2½ pipe diameters from the upper face of the plate, and the downstream 8 pipe diameters from the lower face of the plate. These taps are used to measure high flows with a low differential manometer.

One of the greatest causes of error

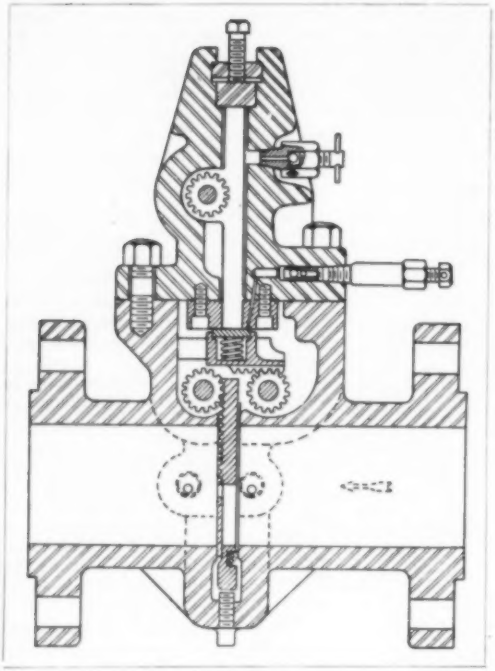


FIGURE 6

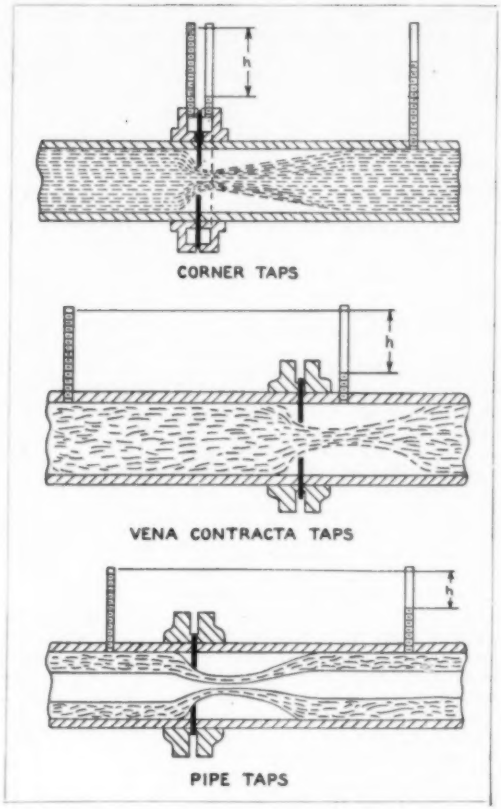


FIGURE 7

in flow measurement when using an orifice plate as a primary device, is in the installation of both the orifice plate and meter. By following a few simple rules, good measurement can be obtained.

1) Always follow AGA recommendations for minimum length of straight pipe required ahead of and beyond orifice plate.

2) Slope all connecting lines between orifice plate and meter 1 inch per foot.

3) Use proper size seal reservoirs. Make sure that seal reservoirs are installed level.

4) Be sure that the flow meter is mounted level.

The foregoing rules are basically applicable to all orifice meter installations; however, a seal reservoir is never used on gas service. Our company uses adjustable orifice fittings almost 100 percent. We have found that there is a short payout on the added cost of the adjustable fitting. By using this type of orifice fitting, no shutdown time is required either to change orifice plates, or to run a scraper.

In brief, the advantages of orifice plates are: 1) Low cost: The orifice plate can be purchased cheaply or made locally. 2) Easily duplicated or interchanged. 3) Complete data available for computing flow, with exception of lines under 2 inches. 4) Ease of installation.

The disadvantages of the orifice plate are: 1) Highest permanent pressure loss. 2) Poor accuracies on high $\frac{d}{D}$ ratios (orifice to pipe diameter). 3) Subject to wear: Abrasives in fluids will wear sharp edge and cause inaccuracies. 4) Obstructs flow of dirt or sediment in line. 5) Can be damaged by foreign matter in line. 6) Requires periodic inspection.

II. Area Flow Meter

Let us now consider the area type of flow meter (Figure 8): An area meter is a flow meter through which a fluid is discharged, under controlled head conditions, through an annular aperture of controlled variable size.

The simplest type of an area meter is the rotameter (Figure 8-A). In this instrument a float of a fixed weight rides in the fluid flow, and through a conical shaped glass tube. The weight constitutes the fixed differential and the area between it, and the tube constitutes the variable area. If there is no flow, the weight or float sinks to the bottom of the tube opposite the zero graduation. The weight of the float is made to conform to the permissible differential in any specific size of the rotameter.

This type of measuring device is one of the simplest available for the measurement of flow. It is admirably suited for all ranges of flow, and is especially suited for flows where a wide range of viscosity is encountered.

From the basic flow equation, $Q = A\sqrt{2gh}$, it is evident that the variations in flow are directly proportional to a change in area, as compared to the square-root proportionality of a change in head. This means a linear calibration instead of a square-root calibration as found in the orifice-type meter.

The rotameter is also used as a viscosimeter and a gravitometer. It is truly the most versatile flow meter available today, as it can be made for

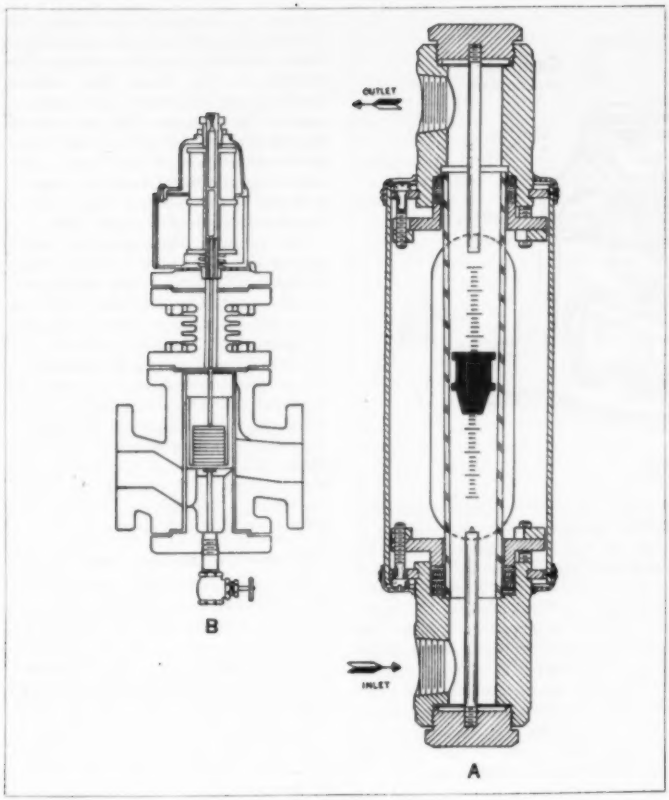


FIGURE 8

any flow rate, for any pressure rating, and is corrosion-proof.

The piston-type area meter (Figure 8-B) employs the same fundamental principle as the rotameter, except that the weight is a balanced piston with a rectangular type of orifice opening. This weight rises and falls with changes in flow exactly as the rotameter weight. This meter is made in limited ranges and is adaptable to flows up to 35 gallons of water per minute, or its equivalent in other fluids.

The advantages of the area-type flow meter are: a) Easily made corrosion-proof. b) High accuracy on all flow rates. c) Fixed pressure loss. d) Uniform calibration. e) Immunity to viscosity changes. f) Visible float is an operation check. g) Low maintenance cost.

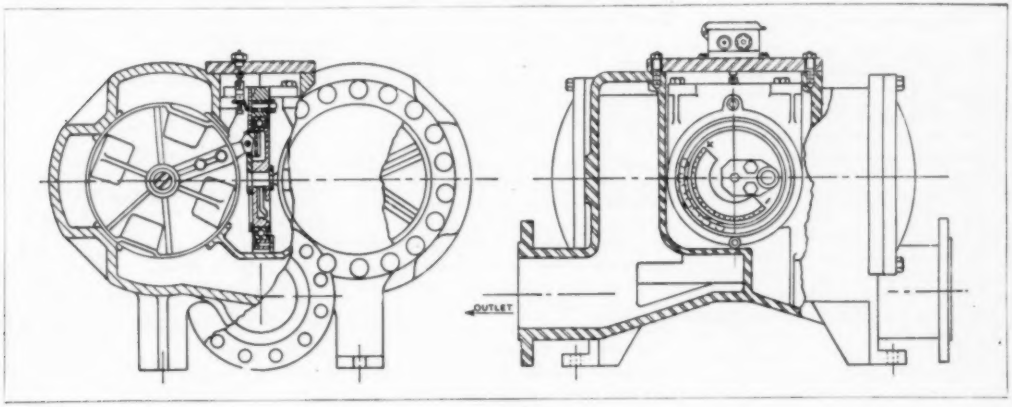
The disadvantages of the area meter are: a) High initial cost. b) Must be installed on a bypass where scrapers are to be run. c) Requires frequent cleaning on some operations. d) Requires special calibration. e) Subject to thermal and mechanical shock.

III. Volumetric Meter

The last type of meter that we shall consider is the volumetric meter. There are several variations in design of this type of meter. We shall consider those that enjoy the widest use in the petroleum industry.

1) *Piston type* (Figure 9): One of the simplest volumetric flow meters, and the one that has the largest number of variations in design, is the piston-and-valve type. Almost any type of piston pump will, if pressure is applied to the fluid in the discharge side, operate as a meter. If the number of the reciprocations of the piston or the number of rotations of the crankshaft is counted, the volume of fluid passing through the system can be computed, provided the dimensions of the cylinder and length of stroke are known. Furthermore, the volumetric efficiency of a pump operating as a meter may be considered as 100 percent, inasmuch as the piston chamber must be completely filled to produce the power to drive the mechanism. Calibration of this type of meter is effected by adjusting either the piston-stroke adjustment or the totalizing counter adjustment.

The piston type of meter is particularly well suited to the measurement of liquids under low heads and low



FIIGURE 9

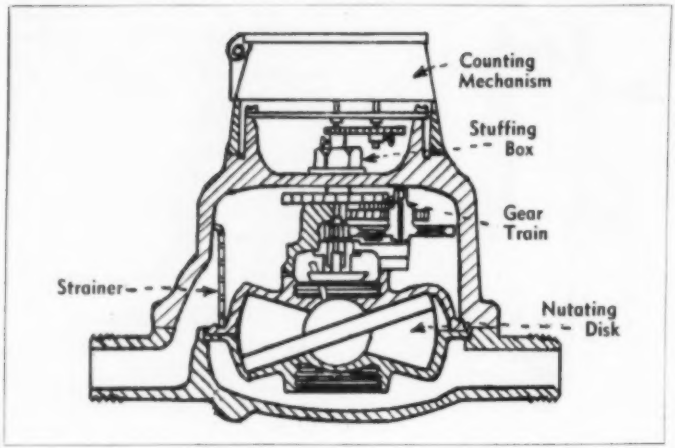


FIGURE 10

flow rates. The lowest flow rate that can be accurately measured is dependent upon the leakage rate.

The leakage past the pistons is an inherent disadvantage of the piston meter. On severe service this meter requires considerable service to maintain 100 percent efficiency. On service where the liquid has no lubricating value, some external means of lubrication should be provided.

The accuracy of the piston meter will vary from 0.1 to 0.3 percent depending on the condition of the fluid. Changes in density and viscosity produce a negligible error.

2. *The nutating-disk flow meter* (Figure 10): This type meter is one of the oldest and one of the most widely used. This is due to the fact that it is a successful instrument for water metering. Its principle is simple, and there are few moving parts. However, to explain its operation other than diagrammatically is almost impossible.

Direct Measure of Flow

The moving part consists of a nutating disk, pivoted in the center of a chamber, which has hemispherical shaped sides and a cone bottom. The inlet is on one side, and the outlet is diametrically opposite. The disk has a vertical centrally-located shaft which fits into the pivot socket in the center of the meter, and rotates about a cone on the top side, the rotation about the cone driving a gear train, which actuates the counting mechanism. The differential pressure of the liquid causes the disk to nutate about the center pivot; and, since the fit between the disk and the hemispherical sides is close, the nutations are a direct measure of the flow.

This meter enjoys wide use in industry, and may be had in sizes to 4 inches. However, its accuracy is not so high as that of the piston-type. This inaccuracy stems from the fact that it is necessary to allow a greater clearance between the disk and the meter walls than is required between the piston and cylinder walls in the piston meter. Calibration is usually effected by changing the ratio of the gear train. However, one type changes the capacity of the hemispherical chamber, by changing the height of the pivot on which the nutating disk rests.

Effect of Gravity Changes

The effect of gravity changes on the nutating-disk meter is negligible. Viscosity changes of from 40 to 700 seconds (Saybolt Universal) will affect the accuracy of a meter of this type as much as 1 percent, during high flow rates.[1] If the meter is calibrated for a medium viscosity fluid, the error caused by viscosity changes usually will not throw it out of commercial tolerance.

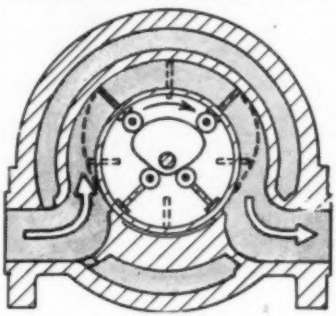
3. *Rotary sliding-valve flow meter* (Figure 11): This type of flow meter is constructed similarly to the standard vane type of vacuum pump. Its design requires that the meter body be in the shape of a closed drum, with a shaft carrying a smaller cylinder arranged to rotate inside the meter body. This shaft is mounted eccentrically with respect to the center of the meter chamber, and the cylinder is slotted to permit the vanes to project from the cylinder to the wall of the meter body. As the center cylinder rotates, the vanes slide in the cylinder slots and are forced against the outside surface of the meter body and, in this way, they seal the meter from any bypass of liquid. The parts on the meter are so arranged as to admit the liquid in the section of the meter body that is farthest from the cylinder. The rotation of the vanes then carries liquid across the meter and forces it out on the opposite side (because of the reduction in volume caused by the eccentric position of the drum) with respect to the meter body. A counter attached to the rotating shaft gives a direct indication of the total flow.

The rotating vanes may be forced against the meter body in many ways. However, two methods are most prominently used. One method is to use compression springs fitted into the cylinder slots. The other method is a mechanical arrangement that maintains the correct position of the vanes. In the latter case a small clearance is provided at all times between the ends of the vanes and the meter body. This reduces the friction in the meter, and also reduces the wear on the meter body that otherwise results from the constant rubbing of the vanes.

Accuracy of Rotary Vane Meter

The rotary vane meter is practically impervious to error from gravity and viscosity changes; and its error, if the meter is kept in good mechanical condition, should not exceed 0.3 percent. Because of large areas subject to wear, and its relatively high rotative speed, dirty fluids are very destructive.

4. *Oscillating-piston meter* (Figure 12): This meter is somewhat similar to the vane-type. It has a drum-shaped body, into which is built a hollow piston that is so arranged to oscillate about a center abutment which is encircled by a confining ring. This ring traps a shaft extending from the center of the oscillating piston. A division plate extends from the meter wall to the center ring, and the piston is slotted to admit this plate. When fluid enters the meter at port *D*, the head pressure forces the piston to oscillate about the outer edge of the meter body, the center shaft at the same time rotating about the annular space between the center abutment and outer confin-



FIIGURE 11

ing ring. As the ports are always open to flow, the movement of liquid through the meter is continuous. In the meter shown in Figure 12, the calibration is effected by a ball race mounted horizontally, concentric with the countershaft and pivoted to tip any desired angle with the horizontal. A pivoted lever, extending from the piston-driven countershaft, extends into this ball race and, if the race is tilted, will oscillate about its pivot as the meter rotates. The magnitude of the oscillations depends on the degree of tilt of the ball race. The oscillating lever is arranged to impart an additional rotation to the countershaft through a ratchet wheel and pawl. Adjustment of this meter is made by varying the tilt of the ball race.

This type of meter is subject to destructive action by dirty fluids. Its accuracy is about the same as the other types mentioned.

5. *Rotating-bucket meter* (Figure 13): This meter has a drum body, with inlet and outlet ports side by side, separated by a baffle or dividing plate. A center cylinder is suspended concentrically inside the meter body, with a close clearance on the sides of the meter chamber and a diameter approximately a quarter smaller than the diameter of the meter body. The flow around the cylinder is restricted by four semi-circular buckets built into flutes in the cylinder surface. These buckets rotate about center pivots, which are fastened to the cylinder. The buckets are gear-driven from a center gear fastened to the meter body, so that they rotate about their own pivots, simultaneously with the rotation of the of the cylinder in which they are mounted. A close tolerance is maintained between these buckets and the meter body, which effects a seal to prevent any bypassing of liquid. As a result of the rotation of the cylinder and buckets, the liquid is trapped in the buckets or between the buckets and is, therefore, volumetrically metered. The number of revolutions of the cylinder is directly proportional to the flow. The accuracy of this meter is comparable to that found in other meters which have been described.

In general, the *positive-displacement meter* has the following *advantages:* 1) High accuracy on low flow rates. 2) Practically impervious to changes in flow, density, viscosity and pressure. 3) Compact and portable. 4) Does not require level mounting.

The *disadvantages* of the positive-displacement meters are: 1) High initial cost. 2) Requires bulky auxiliary equipment. 3) Requires relatively clean fluid. 4) High repair cost. 5) Requires frequent calibration.

Figure 14 shows a typical positive displacement meter installation, used for crude oil measurement.

It is necessary to install the proper strainer and air eliminator equipment with the positive-displacement meter in order to obtain the best accuracy. This equipment can be purchased from the meter manufacturer, or it can be shop fabricated.

In all cases, where a positive-displacement meter installation is being considered, the ASME-API code of recommendations should be followed to assure the best results.

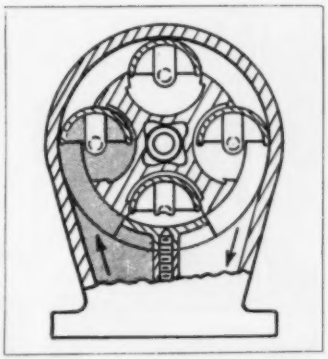


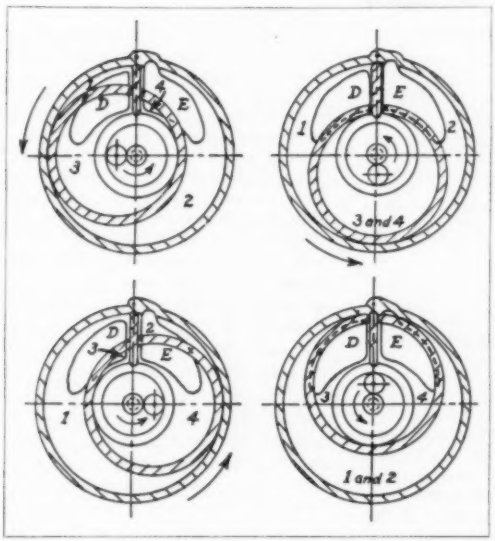
FIGURE 13

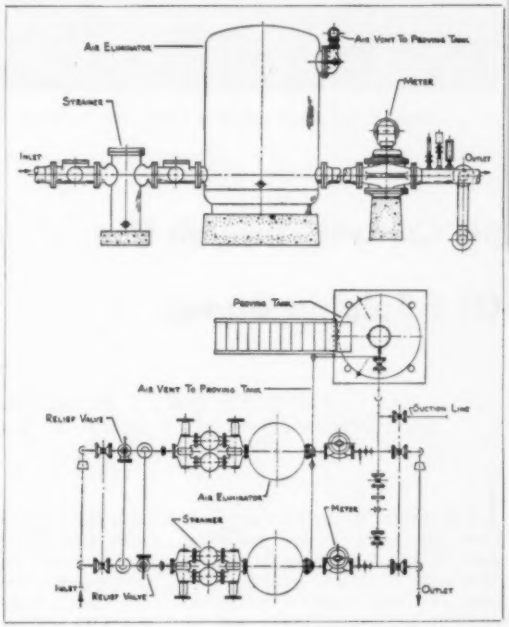
REFERENCE

[4] See *Trans. Am. Soc. Mech. Eng.* **60**, 617, Nov. (1938).

FIGURE 14

FIGURE 12





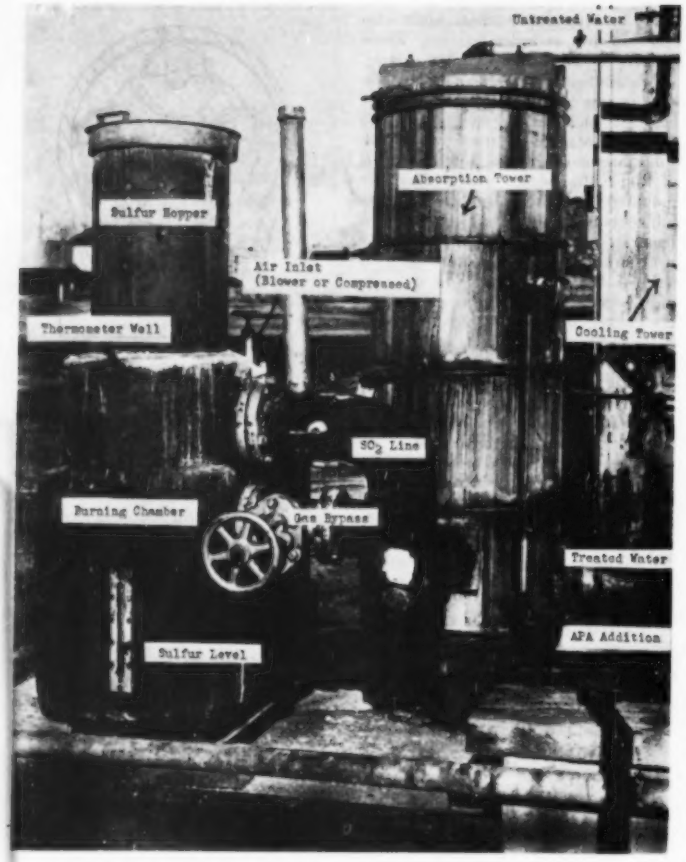


FIGURE 1. Typical Set-Up for Sulfur Burner—APA Treatment of Cooling Tower.

pH Control Through Use Of a Sulphur Burner

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***MILLIONS** of dollars are spent yearly in cleaning and replacing equipment in cooling water systems. In addition, owing to decreased heat transfer in the case of "dirty" equipment there are further losses either in efficiency or capacity amounting to still greater sums. Fortunately, in recent years a better understanding has been reached regarding these problems and improvements are possible. It is the purpose of this article to review this information.*

Presentation was before the California Natural Gasoline Association meeting in Los Angeles in September.

IN DISCUSSING cooling water problems, reference is to any case where water is circulated through or over equipment to absorb or carry away heat. The chief types of equipment involved are cooling towers and related equipment such as engine jacket systems, refrigeration systems, steam condenser systems, air conditioning systems, etc. The systems referred to involve at least three types of cooling water systems classified as follows:

1) Once-through systems, 2) Open circulating systems, and 3) Closed circulating systems.

The names pretty much indicate the difference between the systems. Fortunately the problems involved are about the same for all three systems and are as follows:

a) *Scale and Deposit Formation:* Whenever water is heated or concentrated there is a tendency for materials to come out of solution or precipitate. The materials that precipitate may come out of solution on heating surfaces forming scale or some of the precipitated material suspended in the solution may deposit on the heating surfaces. In either case, decreased heat transfer rate occurs and therefore lower efficiency results. This is probably the most important problem encountered in such systems.

The chief material that precipitates when water is heated or concentrated is calcium carbonate ($CaCO_3$). Some difficulty is also encountered from the precipitation of iron oxide (Fe_2O_3). Both materials result from constituents that are normally soluble in the water. Whether difficulty will be encountered from the precipitation of these materials depends greatly on the pH of the solution. Most of the corrective measures for the prevention of scale and deposit in cooling water systems center around the elimination of the precipitation of these materials or upon the prevention of adherence of any of the materials that precipitate.

b) *Corrosion:* Since most waters contain dissolved oxygen and carbon dioxide, both of which have a tendency to cause corrosion, this problem is often encountered and is discussed later in greater detail. The problem of corrosion is usually combatted by proper pH adjustment.

c) *Algae and Slime:* This problem

is so well known that it requires no explanation. Needless to say, during the "growing season" formation of such growths becomes a real nuisance and large losses result from decreased efficiency and capacity.

d) *Delignification:* This is an apparent rotting of the wood, the lignin and cellulose products being extracted leaving the wood in a stringy mass having little if any strength. This difficulty is caused almost entirely by the action of alkali on the wood. Proper control of the alkalinity or pH therefore is the chief means used to combat the problem.

Previous Corrective Means

The chief factors that affect scale or deposit formation are temperature, rate of heat transfer, calcium, magnesium, silica, sulfate and alkalinity concentrations and especially pH value. Considerable work has been carried out to relate these factors to the problems encountered. By means of Langelier's equations, which take into consideration pH, calcium, total alkalinity, dissolved solids and temperature it is possible to predict with some degree of accuracy whether a water is scale forming or corrosive. The Langelier index is well known in this respect. The basis of the index is whether or not water is saturated with calcium carbonate. If it is, there of course is danger of deposit formation. If it is not, there is little if any danger of deposit formation, but there is danger of corrosion.

Some success has been experienced through the use of this index, but unfortunately its determination and calculation are rather involved which eliminates its use as a field method. Also, it is very difficult to adjust the condition of the water so that it is just non-scale-forming and at the same time not corrosive. For this reason other procedures have been used.

By far the most emphasis has been placed on the use of specific chemicals to prevent the precipitation of materials from the water. The chemicals used are largely of the complex phosphate type. None are 100 percent efficient and some deposits will form, especially if the pH exceeds 8.0 to 8.5. This has led to the incorporation of organic materials along with the phosphates to condition the material that does precipitate so as to make it non-adherent. Again it should be noted that the success of this method depends largely on pH control. In other words, the system is effective only if pH is below the range given. Sulfuric acid and other acidic materials have been used to some extent in an effort to control pH, but their usage has not been generally accepted owing either to hazards involved or to cost.

These chemicals also are advocated to eliminate corrosion if the pH is so low that corrosion will take place, for example, below 7.5. Needless to say, such a low pH in the cooling water itself is seldom encountered.

With respect to delignification, little attention has been given to this problem until recently. Fortunately as discussed later, the remedy is very simple.

A consideration of the shortcomings of the previous corrective means referred to, together with the results of investigative research has led to the adoption of the use of an effective anti-precipitating agent in conjunction with a sulfur burner to control pH for the elimination of cooling water problems. A photograph of the essential equipment involved is shown in Figure 1, and Figure 2 shows a line diagram of a typical installation. Referring to Figure 2, it will be noted that the essential equipment consists of a sulfur burner for forming sulfur dioxide and an absorption tower for absorbing the sulfur dioxide in the cooling water. The anti-precipitating agent is fed into the effluent from the absorption tower. The actual construction, design and usage of the sulfur burner is discussed in greater detail in a bulletin.[1]

The burner is so designed and constructed as to require little care. In fact, once the burner is in operation all that is necessary is to fill the sulfur hopper once a day or so and to adjust the air supply. Either a compressed air line or a blower can be used to supply the air. The amount of air passed through the burner chamber governs the amount of sulfur burned and consequently the amount of alkalinity reduction. The leveling of sulfur in the burner chamber is automatic, all that is necessary being to adjust the gas flow through and around the hopper so as to maintain the molten sulfur in a certain temperature range. A bypass valve is provided for this purpose. The gas passes from the burner to the absorption tower. A part or all

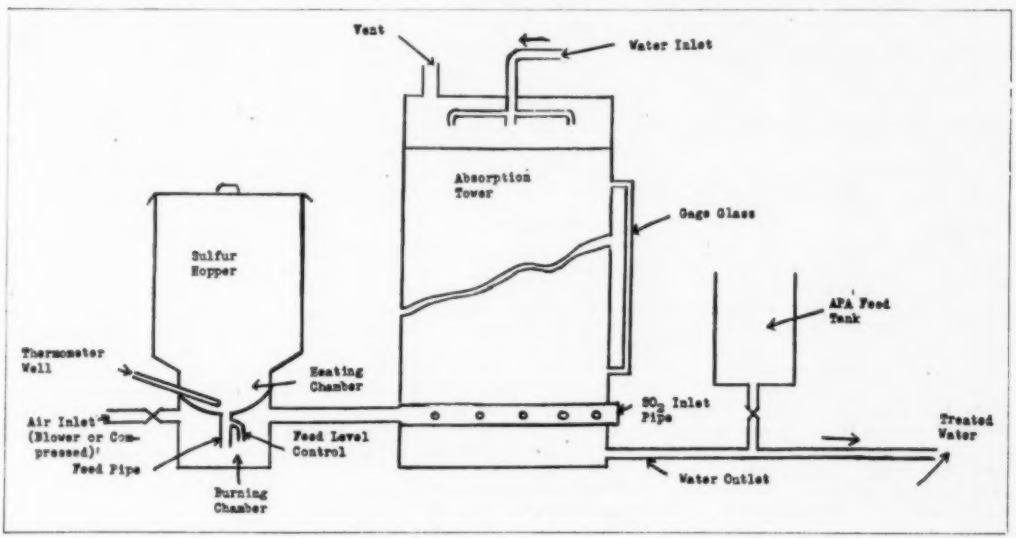

FIGURE 2. Equipment Diagram of Sulfur Burner—APA System for Treatment of Water to Prevent Scale and/or Lower the Alkalinity.

of the water from the heat transfer equipment may be passed through the tower. The tower will handle 100 gallons per minute satisfactorily. This makes possible treating very large volumes of water, for example such as involved in large cooling towers or in large boiler plants since only a small fraction need be passed through the burner-tower combination.

The burners are currently available in three sizes. The large one will burn 3 to 15 pounds of sulfur per hour; the medium size one 1 to 5 pounds of sulfur per hour and the small one 0.2 to 1 pound of sulfur per hour. On the basis of sulfuric acid this corresponds in the case of the large burner to the use of 12.4 to 46.5 pounds of sulfuric acid per hour; the medium sized burner to the use of 3.1 to 15.5 pounds of sulfuric acid and in the case of the small burner to the use of 0.62 to 3.1 pounds of sulfuric acid per hour. Larger burners can be supplied or several of the large size can be used in case more capacity is required.

From a chemical standpoint, in the burner the sulfur is burned to sulfur dioxide—

$$\underset{\text{Sulfur}}{S} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Sulfur Dioxide}}{SO_2}$$

The sulfur dioxide dissolves in the water in the absorption tower forming sulfurous acid—

$$\underset{\text{Sulfur Dioxide}}{SO_2} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sulfurous Acid}}{H_2SO_3}$$

The sulfurous acid formed reacts with any alkalinity present, for example sodium bicarbonate or calcium bicarbonate, neutralizing it—

$$\underset{\substack{\text{Sodium}\\\text{Bicarbonate}}}{2NaHCO_3} + \underset{\substack{\text{Sulfurous}\\\text{Acid}}}{H_2SO_3} \rightarrow \underset{\substack{\text{Sodium}\\\text{Sulfite}}}{Na_2SO_3} + \underset{\text{Water}}{2H_2O} + \underset{\substack{\text{Carbon}\\\text{Dioxide}}}{2CO_2}$$

In reducing alkalinity 0.32 ppm. of sulfur when burned will neutralize 1 ppm. of alkalinity expressed as calcium carbonate. Consequently, 0.32 pounds of sulfur will be required for each ppm. of alkalinity reduction desired for each million pounds of water involved. Expressed on the basis of 1000 gallons, this amounts to 0.0027 pounds of sulfur per ppm. alkalinity reduction desired per 1000 gallons of water involved.

Approximately 3.1 times by weight as much sulfuric acid as sulfur is required for alkalinity reduction. Currently sulfur costs about 0.9 cents per pound and sulfuric acid about 1.6 cents per pound. Consequently, 0.9 cents worth of sulfur will reduce as much alkalinity as 4.9 cents worth of sulfuric acid. On a million pounds of water basis, following are the pertinent data on the relative costs per ppm. reduction:

	Sulfuric Acid	Sulfur
Lbs./ppm. reduction/1,000,000 lbs. H_2O	0.99	0.32
Cost cents/ppm. reduction/1,000,000 lbs. H_2O	1.6	0.29

Consequently, it is obvious that in addition to being more convenient and safe to use, sulfur through the use of the sulfur burner is much cheaper than sulfuric acid for alkalinity reduction. Thus pH control is possible and practical and when the burner is used in conjunction with a proper anti-precipitating agent, scale and deposit formation and corrosion will be eliminated. It should be noted that through the use of the sulfur burner proper pH control is made possible without the hazards and high costs normally involved in previously used methods.

As to algae and slime control, in general fairly satisfactory results have been obtained with materials currently available. The chief materials being used are chlorine and compounds based on chlorine, phenates or compounds based on phenol, copper sulfate, and more recently bromine and complex ammonium compounds. In some cases the organisms build up a tolerance to any one of the materials listed, in which case it may be necessary to switch to one of the others for a short period.

Although too recent for any definite conclusion, there are indications that the use of the sulfur burner will decrease or eliminate the growth of algae and slime. At present it is not known whether the action is one of toxicity or of decreased oxygen content. In any case, in the installations made so far it has not been necessary to use supplementary treatment for algae control.

As mentioned previously delignification of wood is eliminated and prevented through the control of pH with the sulfur burner. A pH of 8.0 to 8.5, which is necessary in any case for scale prevention, insures little if any attack on the wood.

Operating Data

The tables show typical data for plants operating with the sulfur burner.

In the case of Plant A before the use of the sulfur burner, practically every type of treatment was tried but bad scaling occurred because of the high pH. After starting use of the sulfur burner in conjunction with anti-precipitation treatment, the old scale gradually disappeared and no new scale was formed. Also, no corrosion or algae has been experienced.

About the same operating conditions were expeirenced at Plant B.

Before the use of the sulfur burner design terminal temperature differences of 5.0 F. were exceeded values of 16 to 24 F. being common. This condition would often occur in 60 days. Since this tower supplied cooling water for condensers on turbines it is obvious that a serious decrease in efficiency and capacity resulted. With the burner, in general, design conditions are maintained although values as high as 8 F. sometimes occur.

Plant A—Located in California
(Results are in parts per million)

	Make-Up	Main Tower[1]	Main Tower[2]
pH	7.6	8.0	7.5
Phenol-alkalinity ($CaCO_3$)	0	0	0
Total alkalinity ($CaCO_3$)	260	350	99
Hydrate alkalinity ($CaCO_3$)	0	0	0
Total Hardness ($CaCO_3$)	499	1950	1150
Chlorides (Cl)	49	208	103
Sulfates (SO_4)	531	2400	1408
Silica (SiO_2)	19	70	43
Phosphate (PO_4)	0	4	5

[1] Operating as single unit.
[2] Operating with some tower water used as make-up for five other towers.

Plant B—Located in Texas
(Results are in parts per million)

	Raw	Main Tower Basin
pH	7.8	8.2
Phenol-alkalinity ($CaCO_3$)	0	0
Total Alkalinity ($CaCO_3$)	190	200-300
Total Hardness ($CaCO_3$)	105	700-800
Chloride (Cl)	33	120-180
Sulfate (SO_4)	S	540-750

Conclusions

In recent years the chemical and physical aspects of scale and deposit formations and of corrosion in cooling water systems have been fairly well determined. Delignification or deterioration of wood in such systems also is understood. In the cases mentioned, the presence of too much alkalinity, that is a high pH, in the cooling water is the chief cause of the difficulties. In the past, little if anything has been done to correct these situations largely because the acid required is hazardous to use and other acidic materials are too costly. Now owing to the practical application of a sulfur burner and a proper anti-precipitation agent to these problems, a practical solution is possible at little cost and with little maintenance and labor. Proper operation of equipment at high efficiency and capacity and with a minimum of cost and upkeep is thus insured.

REFERENCES

[1] Bulletin dated 1-12-45 RCU, titled "Scale Prevention and Alkalinity Control Through the Use of a Sulfur Burner," available upon request to the authors at 15 East 26th, New York.

For Efficiency–

Designing GAS COMPRESSOR STATIONS

PART II

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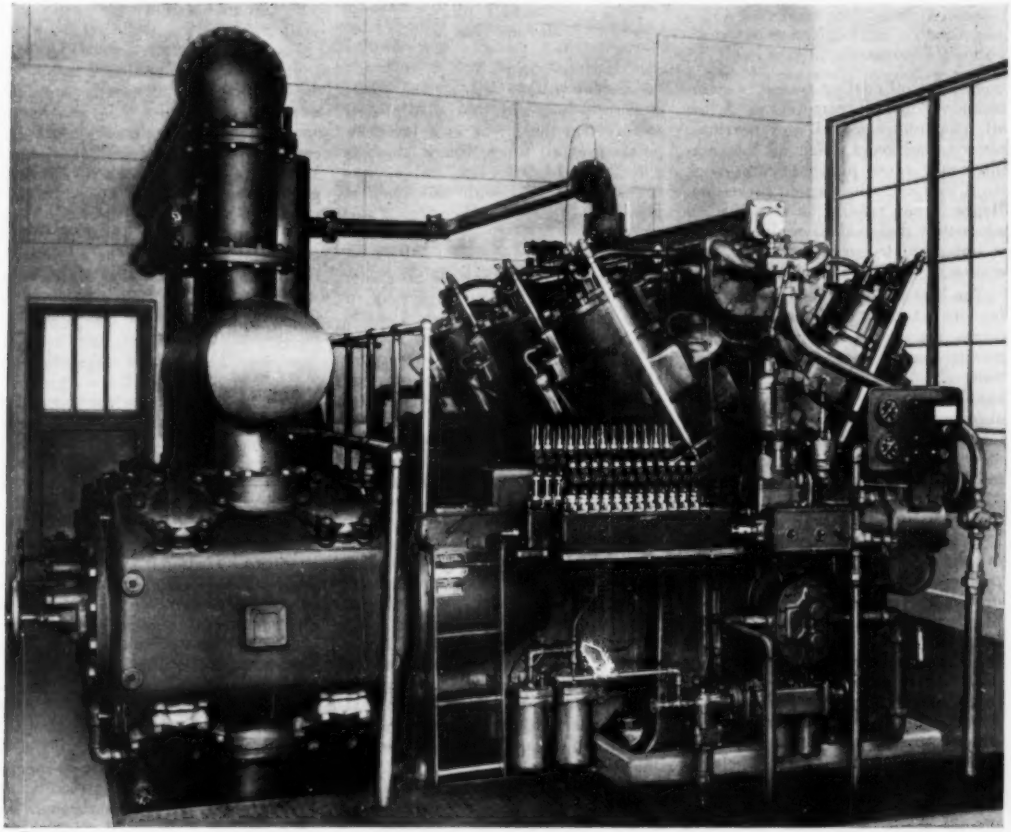
***THE DESIGN** of compressor installations is of high importance to all concerned with refining, natural gasoline, and petrochemical processing plants. The author here concludes an authoritative treatment. Part I appeared in the December issue of PETROLEUM REFINER.*

IN PART I, design of compressor buildings, foundations, and water cooling systems was discussed in terms of modern operating requirements and methods. The oil cooling, air intake, exhaust, and piping systems will be discussed in this article.

Oil Cooling System

Modern gas compressor stations are usually equipped with oil coolers, filters, and cleaning devices. From all standpoints the most important func-

FIGURE 1 (II)
Gas Compressor Installation Showing Gas, Water, Oil and Fuel Piping.



(Photo Courtesy Cooper-Bessemer Corporation)

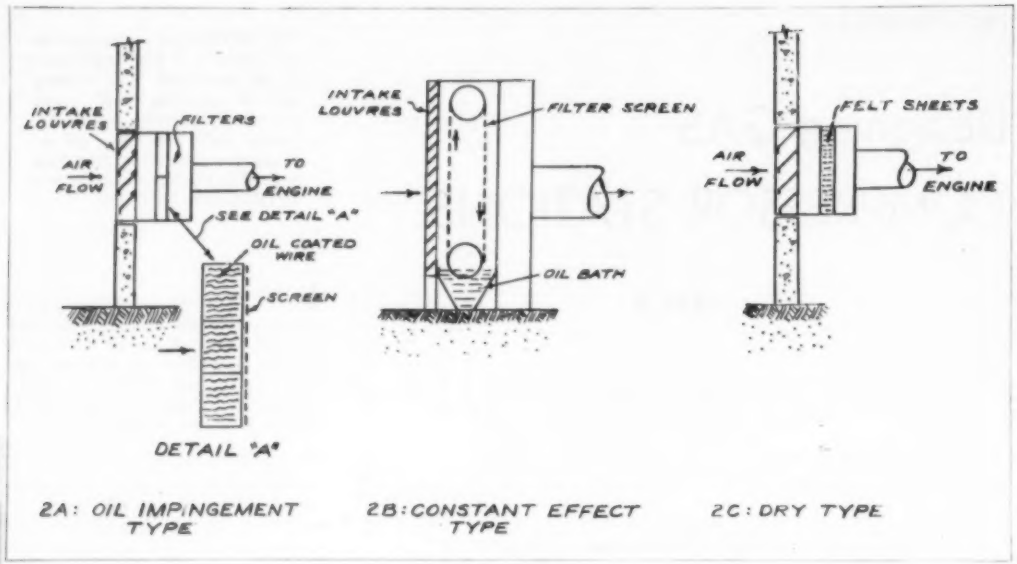


FIGURE 2 (II)
Air Filter Types.

tion of the oil cooling system is maintenance of low oil temperatures. A low oil temperature means cool bearings, pistons, and gears. High oil temperatures may cause piston seizure, stuck rings, and excessive carbon formation. Hence, it can readily be seen that an adequately designed oil cooling system is important to successful station operation.

The heat which the oil absorbs during its passage through the engine comes mainly from friction between moving parts. Under ordinary conditions about 2½ percent of the heat supplied by the engine fuel will be absorbed by the lube oil. With a thermal efficiency of about 30 percent the amount of heat which the oil will have to absorb from the fuel is

$$\frac{2545 \times 0.025}{0.30}$$

or about 200 Btu per brake horsepower hour. This value is frequently used as a basis for preliminary selection of oil cooler capacity. The final choice of an oil cooler is usually based on the amount of oil to be circulated, the maximum allowable oil temperature in the engine, and the builder's recommendations. With a jacket water temperature of 160° F., the maximum oil temperature is usually held at about 140° F.

In engines with oil-cooled pistons, the oil temperature must always be less than the jacket water temperature to prevent piston seizure. The small clearances used with oil-cooled pistons require that the oil be at a low temperature at all times. Hence, there is a tendency to "over-size" oil coolers for engines fitted with this type of piston.

Independent Water System

The water supply for the oil cooler can come from the jacket system or from an independent system. Usually the independent system gives best results because control of water flow rate is simpler and proper oil temperatures can be maintained regardless of jacket water temperature. When the oil cooler is supplied with water from a jacket system there is always a possibility that safe oil temperatures may be exceeded when compressor load is heavy.

Water and oil pressure drops through the oil cooler should be held to minimum values to reduce pumping costs. In general, the ideal oil cooler is that with maximum heat exchange capacity and minimum resistance to fluid flow. Besides these characteristics the cooler should be easy to clean and maintain. A certain amount of sludge will always collect in the oil cooler regardless of how many filters are used in the lube oil system.

Several filters and a centrifuge are used in modern lube oil systems. The filters must be capable of handling the oil requirements of the engine plus the excess which is usually supplied as a safety measure. The maximum amount of oil circulated seldom exceeds 10 gallons per horsepower hour. Mechanical filters of the cloth bag, paper disc, or felt pad type are usually used for lube oil service. They will remove sand, carbon particles, and metal scraps from the oil stream. Centrifuges which continually clean a small portion of oil by-passed from the engine system have been found to be most suitable.

Air Intake System

Next to an effective cooling water system a reliable air intake system is most responsible for reduction of maintenace costs. Dust particles in the air are one of the principal causes of cylinder liner wear. Several studies have shown that an engine using filtered air will operate five to ten times longer without reboring than an engine using unfiltered air. Hence the importance of an effective intake system can readily be seen.

Several types of intake filters have been successfully used in gas compressor stations. These are the oil impingement, constant effect, and dry types. The oil-impingement type, Figure 2A, consists of several layers of wire or metal shavings coated with a special oil to which dust particles readily adhere. Outdoor air passes through the mesh before it enters the engine intake manifold and any dust particles

present adhere to the oil. The cleansing capacity of this type filter progressively decreases. Periodically the mesh must be washed and re-oiled.

The constant effect filter, Figure 2B, has found wider application than any other type because little maintenance is required. It usually consists of a vertical metal filter screen in the shape of an endless belt. The screen is turned slowly by an electric motor and passes through an oil bath at its lower end. Dust particles from the incoming air adhere to the filter screen and are washed off by the oil bath. Hence the cleansing effect is constant.

Dry type filters, Figure 2C, are made of glass wool, felt, or cloth. Some types can be cleaned in place by use of a water hose. Others, of the "throw-away" variety, are discarded when they become ineffective. Maintenance costs on all filters which must be cleaned periodically tend to be slightly higher than for the constant effect type.

During design and selection of air filters and intake ducts, the pressure drop between the outdoor air and engine intake manifold must be carefully checked. Excessive pressure drops in the intake ducts and filters should be avoided because pumping losses in the engine will be increased. As a result the power output of the engine will decrease. Besides a reduction in power output the engine will tend to operate at higher temperatures with the possibility of piston seizure and lube oil carbonization.

Exhaust System

There are two important factors which must be considered during the design of the exhaust system, 1) maximum allowable length, and 2) exhaust line pressures. Two-cycle engines are more susceptible to troubles resulting from excessive exhaust line length than are four-cycle engines. For first approximations during design work it is generally assumed that 8 cubic feet per second of exhaust gases per horsepower developed will be handled. This flow rate is at ordinary exhaust temperatures. A length of about $\frac{5000}{\text{engine rpm}}$ for individual cylinder exhaust lines is often assumed for preliminary design work. If a muffler is to be used in the exhaust line, the equivalent resistance of the muffler in feet of straight pipe must be taken into consideration. The maximum allowable exhaust line length as stated by the engine manufacturer should never be exceeded unless permission is granted to do so.

TABLE 1
Basic safety devices used with gas compressors.

DEVICE	FUNCTION To Sound Alarm and Shutdown Compressor . . .
Overspeed Cutout	. . . when rated speed is exceeded. (Examples: excessive speeds during periods of low or no load operation.)
High Water Temperature	. . . when upper limit of water temperature is exceeded. (Example: high temperatures resulting from circulating pump failure; leak in pipe.)
Reduced Water Flow	. . . when water flow becomes less than normal. (Examples: circulating pump stoppage; leak in pipe.)
Lube Oil Pressure	. . . when lube oil pressure falls below normal. (Examples: leak in pipe; burned out bearing.)
Lube Oil Temperature	. . . when lube oil temperature becomes excessive. (Examples: overloaded compressor; reduced cooling water flow.)

Exhaust line pressures should seldom exceed 3 pounds gage because an increase of 1 psi. back pressure decreases power output about 2½ percent. About 1 percent of this decrease of power output results from increased exhaust work and the remainder from increased clearance gas pressure. The easiest way to obtain low exhaust line pressures is by use of liberal size pipes.

Present gas compressor practice requires an expansion joint between the engine exhaust manifold and the muffler. With this arrangement the exhaust line can be anchored at the muffler. All expansion strains are thereby isolated from the engine and foundation.

Piping

Piping has caused more trouble in gas compressor station operation than any other part of the equipment. The usual errors in piping design and selection result from under-sizing of the lines. For gas compressors with piston speeds of 700 fpm. or less, intake pipe size is usually between 40 and 50 percent of cylinder diameter. The discharge connection size varies between about 33 and 50 percent of cylinder diameter.

Compressor intake and discharge lines should always be sized on the basis of the actual amount of gas flowing to the cylinder per unit time. Actual gas flow is not the product of piston displacement and volumetric efficiency. Instead, it is a function of piston velocity during the period that gas is flowing to the cylinder. Piston velocity, in turn, is dependent upon the compressor rpm. and connecting rod to crank ratio. Hence, the actual flow rate to a compressor can be determined only by an analysis of the unit itself.

Small intake and discharge lines decrease compressor capacity, increase engine fuel consumption, and can cause severe overloading of the engine and compressor. When sizing pipes all restrictions such as intercoolers and after-coolers should be carefully considered. Large pressure drops through such restrictions can be just as detrimental to compressor operation as undersized pipes. Headers connecting several compressors should be sized on the basis of actual gas flow, in a manner similar to the intake and discharge lines.

Safety Devices

Table 1 lists the important safety devices which are generally used in conjunction with compressors today. The overspeed, high lube oil temperature, low lube oil pressure, high water temperature, and low cooling water flow cutouts are the basic safety devices needed in all plants, large or small. Large plants are usually equipped with a greater number of safety devices because equipment investment is high and there are fewer operators per machine. Excessive bearing temperature and wear cutouts, overload stops, high exhaust temperature alarms, and fuel supply cutouts are a few of the devices which find use in larger plants.

The number of safety devices required for a particular station will depend upon station size, relative importance of automatic operation, and the type of controls used for the compressors. Evaluation of these factors in relation to desired station performance will generally show to what extent the protective system must be developed.

Thus, design of economical, efficient, and reliable gas compressor stations is dependent on many factors. Careful consideration of the factors outlined in this article is certain to result in better stations. Since any savings which result are spread over a period of at least 20 years, the time spent on preliminary studies is well worthwhile.

* * *

DR. FRANZ FISCHER

DR. HANS TROPSCH

The Fischer-Tropsch Hydrocarbon Synthesis . . . Its First Development

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PERSEVERANCE and belief in the scope of his discovery enabled Dr. Franz Fischer to see the commercial development of his process despite many discouraging early setbacks. The great importance which the Fischer-Tropsch hydrocarbon synthesis has attained, not only in Germany but all over the world and particularly in this country, will prompt this presentation of some details of the history of the development of this process.

Both Franz Fischer and Hans Tropsch originally had only scientific aims and were not concerned with developing commercial processes. Fischer, a tall scholarly man, fond of good living, was a professor of chemistry at Berlin University and Berlin-Charlottenburg Institute of Technology. Later he was appointed to be the first director of the new Kaiser Wilhelm Institut fuer Kohleforschung in Muelheim/Ruhr (institute for coal investigation), which was largely built on the basis of his suggestions and plans. It was there that Tropsch became his chief assistant.

Though his work at this institute was sponsored not only by the Kaiser Wilhelm Gesellschaft but also by the Ruhr-coal industry, Fischer was absolutely free in his investigations. His only assigned duty was to investigate the origin, properties, and behavior of coal and there was no obligation to develop new processes of technical importance in this field. It was in the course of fundamental research that the two men decided to study in detail the behavior toward hydrogen of carbon monoxide and dioxide, the gaseous products formed in the oxidation and combustion of the carbon of coal. These investigations finally brought about their now famous synthesis of hydrocarbon oils.

The very sound idea practiced in both German industrial and institutional research of that period to allow scientists to investigate freely certain fields of chemistry and physics without consideration of practical results proved most successful in this case.

Fischer's Finding

When Fischer and Tropsch began their investigations on the behavior of the carbon oxides against hydrogen, it was already known for a long time that carbon monoxide can be hydrogenated at elevated temperatures and atmospheric pressure in the presence of certain metallic catalysts to form methane according to the equation:

$$CO + 3H_2 = CH_4 + H_2O$$

(Fischer and Tropsch, Brennstoffchemie, **4** [1923], 193-7; C. A. **18** [1924], 349.) Previous investigators had found that this hydrogenation of carbon monoxide with formation of methane could be obtained by using an iron catalyst at 500-600° C. and by employing nickel or cobalt catalysts at about 380° C. Fischer himself found, and published a short preliminary note, that hydrogenation of carbon monoxide in the presence of metallic nickel could also be obtained at lower temperatures.

Not long after this publication Fischer and Tropsch on further study of the problem found that it was also possible to obtain ethane, ethylene, and higher saturated and unsaturated hydrocarbons from carbon oxides and hydrogen in the presence of metallic catalysts of the VIII transition or iron group of the periodic table at relatively low pressure and moderately elevated temperatures and that mixtures of such metals with certain metal oxides, such as zinc oxide, work even better. While the formation of methane from carbon oxide was of no technical value, it was apparent that the new discovery could form the basis of a process of considerable technical importance. Fischer and Tropsch, therefore, filed on July 21, 1925, a patent application on this hydrocarbon synthesis.

At that time it was the filing date

***CONTINUED** development for the improvement of the basic Fischer-Tropsch process for the synthesis of liquid hydrocarbons from hydrogen and carbon monoxide today occupies an increasing proportion of the efforts of oil industry research and development groups. Heralded by some as the solution to all our problems of liquid fuel supply, the processes have also been discounted by others as not suited to the present needs and economics in this country.*

This brief account of the process development is perhaps not within the usual scope of Refiner articles, but because of the current interest in the process it has been included. The author was well acquainted with both Fischer and Tropsch, having served as patent attorney on some of their patent claims.

of the first patent application deposited at the Patent Office of any one of the countries of the International Convention for the Protection of Industrial Property which determined the priority of a patent application in Germany and not the date of the invention itself, in contrast to the law and practice of the United States.

Convincing the Examiner

The Examiner of the German Patent Office referred to Fischer's above mentioned own prior publication on the treatment of carbon monoxide with hydrogen in the presence of nickel at moderately elevated temperatures, and rejected the claims of the patent application in view of this publication. It took long and difficult discussions and negotiations to convince the Examiner that the possibility of synthesizing higher hydrocarbons by the methods described was not anticipated by Fischer's own prior publication. It could be shown that with the use of nickel alone as a catalyst the tendency for the formation of higher homologues of methane is very small and that it requires in this case closely defined conditions to produce any such homologues (Fischer and Tropsch, Berichte **59B** [1926], 832.)

The claims of the patent application were then restricted in such a manner as to clearly distinguish the invention claimed from the prior publication. The use of pure nickel as a catalyst was excluded from protection, and the temperatures of the reactions were specified to that they should be lower than the temperature at which methane only is formed in the presence of the catalyst employed. These temperatures are different for the different catalysts. The German patent No. 484,337 which was finally granted on the application, and the corresponding first U. S. patent No. 1,746,464 still show the imprint of this story.

Even after the difficulty described above had been surmounted, the Examiner of the German Patent Office was still unwilling to accept the application. In no way did he realize the great scientific and practical importance and the basic novelty of the method. He referred to innumerable unimportant prior publications in an endeavor to show that the Fischer-Tropsch process did not involve invention. It was only after a request from Fischer's side finally to reject the application in order to open the way for appeal that the Examiner finally accepted the application.

Not even this, however, concluded the story of the grant of the patent. According to German Patent Law, and in contrast to the law of the United States, it is possible for anybody to start opposition proceedings at the Patent office before the grant of a patent, by trying to show that claims of a published application do not involve patentable subject matter. In Fischer's case the powerful I. G. Farbenindustrie entered into opposition proceedings and claimed that no invention was involved in the use of low pressures and moderately elevated temperatures in view of the known high pressure methods. The opposition, however, was rejected by the Examiners' Department and an appeal filed by the opponents against this decision was withdrawn for unknown reasons before any further action of the Patent Office was taken. The grant of the patent thus became final.

It is interesting that the I. G. at that time and still later was of the opinion, as shown by the opposition proceedings as well as by discussions and publications, that the Fischer-Tropsch method was of no practical value, particularly in comparison with the process of direct hydrogenation of coal at high temperatures and pressures, the so-called liquefication of coal by the Bergius method.

Even in the Ruhr coal industry which sponsored Fischer's institute and which later became the founder of the Ruhr-Chemie A. G. where the Fischer-Tropsch process was first operated on a commercial scale, the opinion prevailed in the beginning that the very large volumes of gas to be handled in this process at a relatively low pressure would make this method impracticable from a technical point of view. However, Franz Fischer was always confident that his process had a great future and employed all his energy to realize the technical exploitation of his idea. He was also convinced from the very beginning that it was not only carbon monoxide obtained by partial oxidation of coal which was important as a starting material in this synthesis, but that natural gas abundant in some countries, could be utilized.

Importance Recognized

After several years of experimentation with a pilot plant erected at the Kaiser Wilhelm Institut, the realization of the possibility of an approaching war made industry see the practical importance of a process which would allow the synthesis of large quantities of petroleum products from native coal, a process which would make Germany to a large extent independent of the import of petroleum oils. A threatening shortage of natural petroleum as well as military considerations are now being brought forward in this country for the erection of large plants utilizing the Fischer-Tropsch synthesis which has vastly improved since its early stages by the lasting endeavors not only of the original inventors, but also of numerous other investigators here and abroad.

Hans Tropsch, who left the Kaiser Wilhelm Institut some years after his participation in this discovery, came after a brief return to his native Czecho-Slovakia to the United States and worked with Universal Oil Products Company. He died too early to see the full fruits of his discovery. Franz Fischer, on the other hand, remained as the head of the Mulheim institute until he resigned after reaching retirement age, and lived to see large scale exploitation of his process in Germany as well as destruction of part of the plants during the war.

Biographical

FRANZ FISCHER was born on March 19, 1877, in Freiburg (Baden), Germany. He studied Chemistry and electrical engineering at the University and Technische Hochschule of Munich, received his doctor's degree in 1899 and then worked for about a year at the Moissan laboratory in Paris. In 1905 he became an assistant of Emil Fischer, Berlin, who, incidentally, was not a relative. He stayed there till 1910, became an instructor and received the title of professor. His work at Berlin University mainly concerned the formation of ozone, hydrogen peroxide, nitrogen oxide, etc. In 1911 he became professor of electro-chemistry at the Technische Hochschule of Charlottenburg. In 1913 he went to Muehlenheim/Ruhr where the Kaiser Wilhelm Institut fuer Kohleforschung was built according to his plans and was opened under his presidency in 1914. There he first worked on the carbonization of coal at relatively low temperatures, on extraction of coal, on montan wax (together with H. Tropsch), on oxidation of coal, and on the theory of the origin of coal from lignine, the "lignine-theory." He then invented the "synthol-process" for production of mixed alcohols, aldehydes, ketones and acids by passing water-gas rich in hydrogen over iron type catalysts at high pressures and relatively high temperatures. Thereafter he invented, together with H. Tropsch, the synthesis of higher hydrocarbons. This synthesis Fischer has rightly compared with nature's process of the synthesis of complex organic compounds by the assimilation of carbon dioxide in the presence of the chlorophyll of plants as the catalyst. Later he proposed the synthesis of acetylene and benzene by partial thermal decomposition of methane. Most of Fischer's work at the Muehlheim institute has been published or reprinted in his "Abhandlungen zur Kenntnis der Kohle." He died in December, 1947, after having retired some years before.

HANS TROPSCH was born in Czechoslovakia on October 7, 1889, was graduated 1912 from the German Technische Hochschule in Prague and received his Ph.D. there in 1913. From 1920 to 1928 he worked with Franz Fischer at the Kaiser Wilhelm Institut in Muehlheim. In 1928 he was commissioned by the Czechoslovakian government to organize and head a national coal research institute in Prague, which he directed until 1931. Then he came to the United States and worked as an associate director of research of United Oil Products Company. In addition, he was a professor of chemistry at the University of Chicago and at Armour Institute, Chicago. He died after a long illness on October 8, 1935.

THE EFFECTS of pressure on the enthalpy of hydrocarbons may be found experimentally or calculated from P-V-T data. One way to express the effect of pressure is the Joule-Thomson coefficient, which has been computed for several hydrocarbon systems and compared with measured values in this installment. The computations are made by means of a new generalized chart, which the author presents herewith.

Applications of THERMODYNAMICS To Hydrocarbon Processing

PART XV—Joule-Thomson Effect

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IN THE development of tables and charts of thermodynamic properties for hydrocarbon systems (pure components and mixtures), the effects of pressure are of great importance but difficult to evaluate. Experimental and calculation procedures are both involved in obtaining the pressure corrections to the entropy and enthalpy, these two properties being the ultimate goals in the preparation of charts and tables. Joule-Thomson coefficients are frequently intermediate steps in this development. So are heat capacities at higher pressures than ideal gas state condition.

From P-V-T data the isothermal pressure correction to the entropy may be and, in fact, must be computed as the entropy cannot be measured experimentally. This may be done for specific hydrocarbon systems or it may be done in a generalized manner. The isothermal effect of pressure on heat capacity may be obtained experimentally or it may be calculated from P-V-T data. A generalized correlation giving the isothermal pressure correction to heat capacity was given as Figure 38 in Part XIII, (PETROLEUM REFINER, November, 1948.) In the next installment analogous correlations will be presented for the entropy and enthalpy. In the current chapter the Joule-Thomson coefficient and methods of computing it will be discussed.

There are three ways of finding the effect of pressure on the enthalpy: a) calculations from P-V-T data, b) measurements in an adiabatic throttling calorimeter, and c) measurements in an isothermal throttling calorimeter. Each of these methods has advantages and disadvantages, as follows:

The effect of pressure on the enthalpy is calculated from P-V-T data by differentiation, which is a source of reduction in accuracy. However, P-V-T data may be very precisely measured so that the reduction in accuracy suffered in differentiation can be tolerated.

Measurements in an adiabatic throttling calorimeter are better known as the "Joule-Thomson Effect." In this experiment the change of temperature with change in pressure at constant enthalpy is measured. This is done by expanding gas from a higher to a lower pressure in a thermally isolated expansion unit, called the "porous plug," measuring the change in temperature accompanying the throttling. With a difference in temperature in the unit it is difficult to obtain precise results because of the difficulty in running the experiment perfectly adiabatically. Furthermore, the translation of Joule-Thomson coefficients into the isothermal pressure correction to the enthalpy requires heat capacity information, which is another source of error. An advantage however, is that only intensive properties, namely pressure and temperature, are measured in the experiments. Sage and Lacey and their collaborators[1, 2, 3, 4, 6, 13, 14] measured Joule-Thomson coefficients for nine hydrocarbon systems. Brown et al[7, 8, 9] also measured Joule-Thomson coefficients for a few hydrocarbons.

Measurements in an isothermal throttling calorimeter give the pressure correction to the enthalpy directly. In this experiment the gas is expanded from a high to a low pressure with the simultaneous addition of sufficient heat to keep the temperature constant. Maintaining constant temperature can be done precisely, thus giving this method an advantage over the classic Joule-Thomson experiment. However, the heat input must be accurately measured along with the pressure change. This requires measuring the flow rate accurately. These two extensive measurements, i.e. quantities of fluid and heat flowing per unit time are the objections to this procedure. With care these measurements can be accurately made. The principal advantage in this method of obtaining the isothermal pressure correction to the enthalpy is that it gives the desired answer directly thus avoiding calculations involving heat capacities, etc. Gilliland and Lukes[5] measured the effect of pressure on the enthalpy of benzene in this way.

In the most precise and complete work on the evaluation of thermodynamic properties, such as the preparation of the Steam Tables and Mollier Diagram, experimental measurements are used to supplement computations from P-V-T data. Hydrocarbon systems are so complex and numerous that this checking by two methods is not possible. On the contrary it is necessary to make many generalizations and shortcuts that suffer in accuracy but have the advantages of versatility and convenience.

Joule-Thomson coefficients have been measured for several hydrocarbon systems. From these data, plus the heat capacities, the isothermal effect of pressure on the enthalpy may be computed and compared with generalized methods. Also values of the Joule-Thomson coefficient obtained from generalized correlations may be compared directly with the measured values of Joule-Thomson coefficient. Thus, we will show the accuracy and limitations of generalized methods in two ways.

Watson and Smith[15] published in 1936 a generalized Joule-Thomson coefficient function. A similar and improved correlation has been developed and is presented in this chapter.

Joule-Thomson Experiments

In 1853 Thomson (known also as Lord Kelvin) devised the classical porous plug experiment and collaborated with Joule in making the test runs, which were continuous rather than intermittent as was the Gay-Lussac-Joule experiment. The gases were expanded slowly through a porous

plug and the entire apparatus was thermostated to avoid external effects.

Improvements in experimental technique have been made by those using this experiment since the original demonstration. The porous plug has evolved from a boxwood tube plugged with cotton wool and silk fibre to a fine-grained alundum thimble, the latter being used by Roebuck[10, 11, 12] on air and other fixed gases and by Sage and Lacey on hydrocarbons. Gilliland and Lukes[5] used a capillary tube in the isothermal throttling of benzene. In the Joule-Thomson experiments the expansion unit must be a poor conductor of heat while this is not required in the isothermal throttling.

Equations

The fundamental and generalized equations for the Joule-Thomson coefficient have been developed and discussed in previous installments (Parts III and XI, PETROLEUM REFINER, September, 1947, and May, 1948, respectively.) The basic equation is

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H = \frac{\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]}{C_P} = -\frac{\left(\frac{\partial H}{\partial P}\right)_T}{C_P} \quad (66)$$

The generalized equation for the Joule-Thomson coefficient is

$$\mu = \frac{\alpha_c\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{Pr}\right]}{C_P} \quad (232\text{-A})$$

It has been shown that $\frac{P_c \alpha_c}{T_c} = 1.44$ and that $C_P = C_{P_0} + \Delta C_P$, where C_{P_0} is the ideal gas state heat capacity and ΔC_P is the isothermal pressure correction given in Figure 38. Combining gives

$$\mu = \frac{1.44\,\frac{T_c}{P_c}\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{Pr}\right]}{C_{P_0} + \Delta C_P} \quad (302)$$

Equation 302 gives the Joule-Thomson coefficient a function of two generalized functions, ΔC_P and

$$\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{Pr}\right],$$

one specific function, C_{P_0}, and a characterizing constant, T_c/P_c. The units of the Joule-Thomson coefficient, from equation 302, will be the same as the units of T_c/P_c, i.e. °R/psia. If T_c and P_c are shifted to the left side, the result would be a Joule-Thomson coefficient in reduced units, as follows:

$$\left[\frac{P_c}{T_c}\mu C_P\right] = 1.44\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{Pr}\right] \quad (303)$$

In 1936 Watson and Smith[13] published a generalized correlation for the function $\left[\frac{P_c}{T_c}\mu C_P\right]$, obtaining it from the relationship

$$\left[\frac{P_c}{T_c}\mu C_P\right] = T_r\left[\frac{\partial\left(\frac{H^\circ - H}{T}\right)}{\partial T_r}\right]_{Pr} \quad (304)$$

where the enthalpy correction term $\left(\frac{H^\circ - H}{T}\right)$ was found from a generalized compressibility factor correlation via the activity coefficient. Equation 303 is a more direct and precise method of evaluating this function.

From equation 66 it can be seen that the isothermal effect of pressure on the enthalpy is

$$\left(\frac{\partial H}{\partial P}\right)_T = -\mu C_P \quad (66\text{-A})$$

With values of μ and C_P, at the desired pressure and temperature, the value of $(\partial H/\partial P)_T$ may be calculated. With both μ and C_P to evaluate, either by experiments or by calculations, the possible errors may double unless care is exercised. If calculations from P-V-T data is the procedure being used to get the isothermal effect of pressure on the enthalpy, there would be no point in evaluating μ and C_P. Instead the equation used would be

$$\left(\frac{\partial H}{\partial P}\right)_T = \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right] \quad (65\text{-A})$$

or the corresponding generalized form.

It is possible to obtain values of C_P from values of μ (over a range of pressures and temperatures) and the ideal gas heat capacities, C_{P_0}. Sage and Lacey[1, 2, 3, 4 and 14] computed C_P from values of μ in some of their work. The equation for making this derivation is obtained by differentiating equation 66-A with respect to temperature with pressure constant as follows:

$$\left(\frac{\partial\left(\frac{\partial H}{\partial P}\right)_T}{\partial T}\right)_P = -\left(\frac{\partial \mu C_P}{\partial T}\right)_P$$

The order of differentiation may be changed in the left hand term and the term $(\partial H/\partial T)_P$ replaced by its equivalent C_P, giving

$$\left(\frac{\partial C_P}{\partial P}\right)_T = -\left(\frac{\partial \mu C_P}{\partial T}\right)_P \quad (305)$$

This is the equation Sage and Lacey, et al used to obtain C_P from values of μ and C_{P_0}. The solution of equation 305 is accomplished stepwise, starting at the ideal gas state, where $C_P = C_{P_0}$, with C_{P_0} being known. As graphical stepwise calculations are made with increasing pressure, using the value of C_P from previous step and the observed value of μ, a curve of C_P vs P for each temperature is obtained.

It is of interest to compare equation 305 with the equation developed in Part III for the isothermal pressure correction to the heat capacity. This previous equation (see note) was

$$\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P \quad (72)$$

(Note: The generalized solution of equation 72 was given in Table 20 (Part XII) and in Figure 33 (Part XIII). Equation 246 (Part XII) has one term missing. It should read

$$\Delta C_P = 1.44\ T_r \int_0^{P_r}\left(\frac{\partial^2 \alpha_r}{\partial T_r^2}\right)_{Pr} dP_r$$

T_r is also omitted from the same equation in Table 16.)

There is no point in equating right hand terms of equation 305 and 72 as is suggested by a visual examination.

In 1936, Watson and Smith[15] published a generalized correlation for the isothermal effect of pressure to C_P, which was developed from the following reationship

$$C_{P_0} - C_P = \left(\frac{H^\circ - H}{T}\right) + \left[\frac{\partial\left(\frac{H^\circ - H}{T}\right)}{\partial \ln T_r}\right]_{P_r} \quad (306)$$

Where the enthalpy correction term $\left(\frac{H^\circ - H}{T}\right)$ was found in the manner described in connection with equation 304. The procedure used in Parts XII and XIII (PETROLEUM REFINER, June and November, 1948) for evaluating the isothermal effect of pressure on heat capacity is more direct and more accurate.

A useful relationship for the adiabatic throttling (i.e. constant enthalpy) process may be obtained from equation 302 by replacing μ by its equivalent $(\partial T/\partial P)_H$, which is equal to

$$\frac{T_c}{P_c}\left(\frac{\partial T_r}{\partial P_r}\right)_H,$$

and rearranging, as follows:

$$C_P d\,T_r = 1.44\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{Pr}\right] dP_r \quad (306)$$

If mean values of C_P and the α_r function are used for a constant enthalpy path, the integration of equation 306 to find the final temperature is very simple, giving

$$T_{r_2} = T_{r_1} + \frac{\left[\frac{P_c}{T_c}\mu C_P\right]_{mean}}{[C_{P_0} + \Delta C_P]_{mean}}\left[Pr_2 - Pr_1\right] \quad (307)$$

Equation 307 is only partly generalized, the C_{P_0} term being specific for the fluid in question.

Equation 307 is useful in calculat-

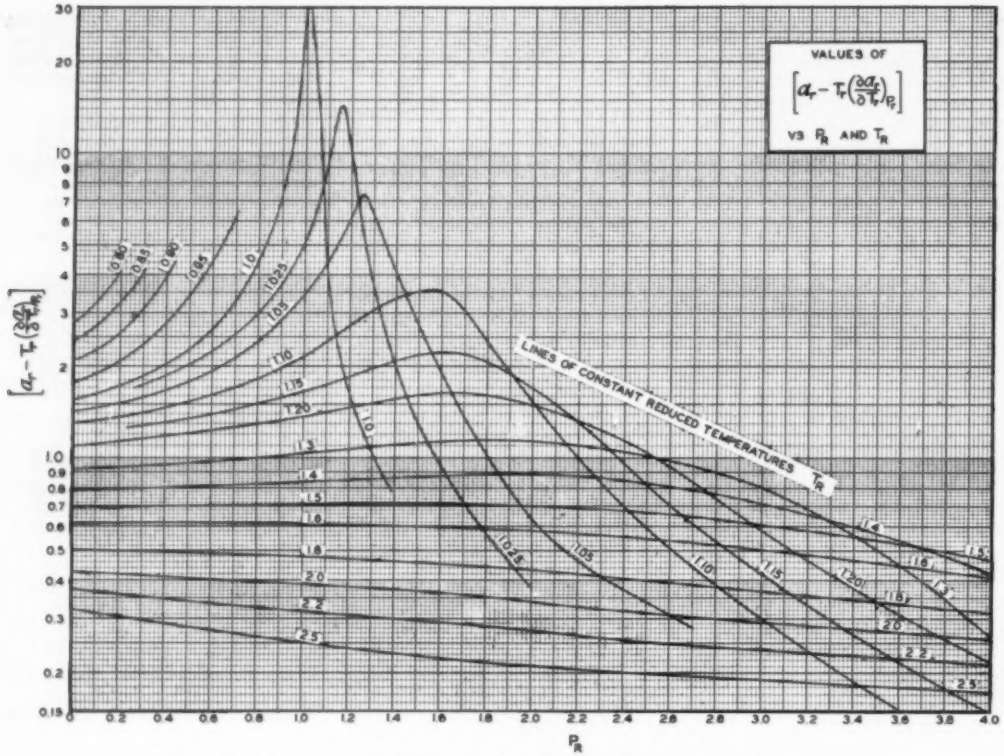

Figure 46. Generalized Volume Residual Function for Calculating Joule-Thomson Coefficient for Gases.

ing the temperature of a gas after throttling, where there is no Mollier diagram available for the gas. It must be solved by trial and error, i.e. assuming the final temperature, solving equation 307 and then revising the assumption for the next trial if necessary.

Generalized Function of Joule-Thomson Coefficient

As can be seen by equation 303 it is not possible to have a completely generalized Joule-Thomson coefficient. However, it is possible to prepare a generalized function of the product of μ and C_{P_0}, which function must include the critical pressure and temperature in the same units as used for μ. Figures 46 and 47 represent such correlations.

Figure 46 gives values of

$$\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r}\right]$$

as a function of T_r and P_r. This chart was prepared from values of the α_r and $\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r}$ terms from Table 20.

Figure 47 was prepared from Figure 46 by multiplying values of the ordinate of Figure 46 by the constant 1.44, giving a solution to equation 303. Figure 47 is similar to a chart published in 1936 by Watson and Smith.[15]

An example will illustrate the application of Figure 47 in the solution of equation 303.

Problem:

Find the Joule-Thomson coefficient for propane at 220° F. and 550 psia.

Solution:

From Table 13 the critical values of methane are found as $T_c = 666°$ R. $P_c = 618$ psia. The reduced conditions are

$$T_r = \frac{220 + 460}{666} = 1.02$$

$$P_r = \frac{550}{618} = 0.89$$

The value of C_{P_0} at 220° F. is 21.5, which is found from Figure 37.

From Figure 38 the value of ΔC_P at $T_r = 1.02$ and $P_r = 0.89$ is found as 20.0

From Figure 47 the value of $\left[\frac{P_c}{T_c}\mu C_P\right]$ at $T_r = 1.02$ and $P_r = 0.89$ is found to be 6.0

The value of μ is found as follows:

$$\mu = \frac{T_c}{P_c}\left[\frac{\frac{P_c}{T_c}\mu C_P}{[C_{P_0} + \Delta C_P]}\right] = \frac{666}{618}\left(\frac{6.0}{21.5 + 20.0}\right) = 0.156 \frac{°R}{psia.}$$

This value is in good agreement with the value of 0.1557 found experimentally by Sage, Kennedy and Lacey[16]. This good agreement should not be taken as indicative of the accuracy of this generalized method, from which highly precise results cannot be expected.

Problem:

As an example in the use of Figure 47 to solve equation 307, the final temperature will be found for the throttling of propane from 450 psia and 200° F. to 200 psia.

Solution:

Assume $t_2 = 160°$ F.

Find reduced conditions:

	Initial	Final
T_r	0.99	0.93
P_r	0.73	0.325

Find Heat capacities:

	Initial	Final
C_{P_0} (Fig. 37)	21.0	19.8
ΔC_P (Fig. 38)	15.0	4.5
C_P	36.0	24.3
Arith. Mean	30.1	

Find values of $\left[\frac{P_c}{T_c}\mu C_P\right]$ from Figure 47

Initial	5.7
Final	3.9
Arith Mean	4.8

Substituting in equation 307

$$Tr_b = 0.99 + \frac{4.8}{30.1}\,[0.325 - 0.73]$$

$$Tr_b = 0.99 - 0.06 = 0.93$$

$$t_b = (0.93)(666) - 460 = 160° \text{ F.}$$

which agrees with the assumed value of 160° F. for t_b.

For such a wide difference between initial and final temperature, it would appear to be better to solve equation 307 stepwise rather than in one overage calculation with mean values of the heat capacity and generalized functions. However, the above example indicates that the average solution for a path is satisfactory.

Comparison of Calculated with Measured Values of Joule-Thomson Coefficient

Joule-Thomson experiments have been made on methane, propane, *n*-butane, *n*-pentane, methane-ethane mixtures, methane-propane mixtures, methane-butane mixtures, and two natural gases by Sage and Lacey, et al. The range of Sage and Lacey's has been low temperatures (70 to 310° F.) and the corresponding equilibrium pressures, such as encountered in petroleum production. The low temperatures limit the usefulness of the data somewhat but it is still valuable data. These data were used in checking the proposed generalized method of computing Joule-Thomson coefficients. For the mixtures Kay's pseudo-critical temperature and pressure, as found by equations 193 and 194 in Part X, (PETROLEUM REFINER, April, 1948) were used in calculating the reduced conditions for applying Figures 38 and 47.

Calculated values of the Joule-Thomson coefficients are compared with the observed values for the pure hydrocarbons in Tables 21 through 24 and for the mixtures in Tables 25 through 29. Except for the two natural gases, the compositions and pseudo-criticals for the mixtures are given in the tabulation with the Joule-Thomson coefficients. Table 28 gives these data for the natural gases.

The average deviations of the calculated coefficients from the observed values are shown in "Derivation Table," column 1, this page.

These average deviations include about twice as many points as given in Tables 21 through 28, i.e. these tables only summarize the results. Points along the saturated vapor curve were included. These are a very severe test for the proposed method. In this connection it is of interest to point out that most of the Sage and Lacey work was near the two phase region. Properties in this region are most difficult to generalize. Accordingly the proposed method is better, on the whole, than indicated by these deviations. These deviations that the proposed generalized method of computing Joule-Thomson coefficients is not very precise for either pure components or mixtures.

The Joule-Thomson coefficient is not

Deviation Table

SYSTEM	Average Deviations Percent
Methane	3.1
Propane	6.3
n-Butane	9.0
n-Pentane	6.6
Methane-Ethane Mixtures:	
36.7 weight percent Ethane	4.7
55.5 weight percent Ethane	4.5
83.8 weight percent Ethane	11.1
Methane-Propane Mixtures:	
34.48 weight percent Propane	7.1
50.66 weight percent Propane	8.4
78.42 weight percent Propane	9.6
Methane-*n*-Butane Mixtures:	
10 weight percent *n*-Butane	8.7
20 weight percent *n*-Butane	5.0
50 weight percent *n*-Butane	7.4
Natural Gas A	4.9
Natural Gas B	4.3

TABLE 21
Joule-Thomson coefficient for methane

Pressure psia.	Temperature °F.	μ, °F./psia. obs. [9]	Calc.
250	100	0.0459	0.0481
250	220	0.0293	0.0321
500	100	0.0461	0.0453
500	220	0.0295	0.0304
750	100	0.0447	0.0439
750	220	0.0285	0.0289
1000	100	0.0424	0.0418
1000	220	0.0268	0.0274
1250	100	0.0394	0.0387
1250	220	0.0244	0.0250
1500	100	0.0360	0.0356
1500	220	0.0220	0.0231

TABLE 22
Joule-Thomson coefficient for propane

Pressure psia.	Temperature °F.	μ, °F./psia. obs. [10]	Calc.
25	100	0.1824	0.217
25	220	0.1000	0.112
50	100	0.1995	0.224
50	220	0.1040	0.113
100	100	0.2242	0.240
100	220	0.1100	0.1126
150	100	0.2475	0.255
150	220	0.1158	0.1168
200	220	0.1225	0.1182
300	220	0.1343	0.1454
400	220	0.1458	0.1371
500	220	0.1540	0.1521

TABLE 23
Joule-Thomson coefficient for n-butane

Pressure psia.	Temperature °F.	μ, °F./psia. obs. [9]	Calc.
30	160	0.1772	0.206
30	220	0.1200	0.155
40	160	0.1988	0.218
40	220	0.1310	0.156
60	160	0.2184	0.226
60	220	0.1412	0.162
80	160	0.2362	0.238
80	220	0.1512	0.168
100	160	0.2526	0.248
100	220	0.1608	0.170
125	220	0.1720	0.180
150	220	0.1830	0.190
175	220	0.1947	0.199

TABLE 24
Joule-Thomson coefficient for n-pentane

Pressure psia.	Temperature °F.	μ, °F./psia. obs. [9]	Calc.
20	220	0.1802	0.204
30	220	0.1950	0.208
40	220	0.2090	0.213
50	220	0.2214	0.220
60	220	0.2328	0.224
70	220	0.2432	0.236
80	220	0.2528	0.239

TABLE 25
Joule-Thomson Coefficients for Methane-Ethane Mixtures

Temperature °F.	36.7 WEIGHT PERCENT ETHANE T_{pc} = 390° R, P_{pc} = 681 psia.			55.5 WEIGHT PERCENT ETHANE T_{pc} = 422° R, P_{pc} = 698 psia.			83.8 WEIGHT PERCENT ETHANE T_{pc} = 488° R, P_{pc} = 700 psia.		
	Pressure, psia.	μ, °F./psia. obs. [9]	Calc.	Pressure, psia.	μ, °F./psia. obs. [9]	Calc.	Pressure, psia.	μ, °F./psia. obs. [9]	Calc.
70	311.8	0.0702	0.0711	326	0.0843	0.0840	264	0.1191	0.109
	793.5	0.0672	0.0648	610	0.0849	0.0820	575	0.1274	0.116
	1259.0	0.0576	0.0566	1060	0.0746	0.0718	1062	0.0680	0.116
100	288	0.0609	0.0608	305.8	0.0733	0.0724	454	0.1058	0.0978
	567	0.0607	0.0582	588	0.0734	0.0684	856	0.1036	0.0935
	997	0.0560	0.0540	1047	0.0669	0.0655	1204	0.0723	0.0720
	1492	0.0468	0.0471	1498	0.0629	0.0535	1437	0.0479	0.0515
160	347.5	0.0468	0.0471	326	0.0560	0.0566	339	0.0767	0.0752
	781.3	0.0466	0.0438	670	0.0556	0.0533	702	0.0781	0.0730
	996.4	0.0466	0.0437	1092	0.0515	0.0495	1046	0.0739	0.0692
	1508	0.0382	0.0380	1482	0.0457	0.0436	1465	0.0580	0.0569
220	315.2	0.0377	0.0389	306	0.0443	0.0440	413	0.0598	0.0628
	763	0.0367	0.0354	617	0.0444	0.0423	872	0.0599	0.0545
	1292	0.0334	0.0324	1060	0.0415	0.0394	1247	0.0560	0.0521
	1544	0.0313	0.0296	1252	0.0400	0.0369	1484	0.0511	0.0485

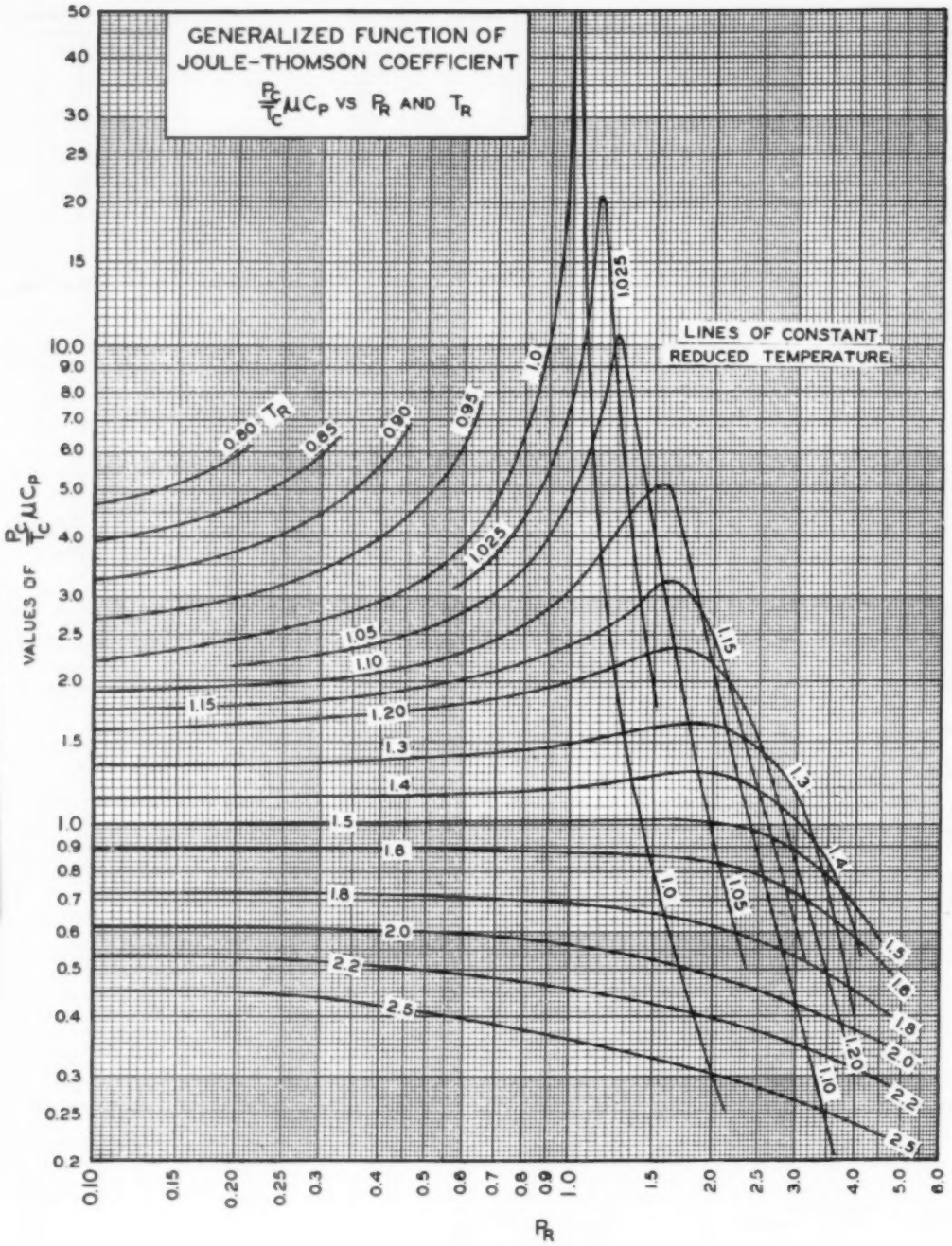

FIGURE 47
Generalized Function of Joule-Thomson Coefficient for Gases.

a very significant property on which to test the generalized method of calculating the effect of pressure. It would be much better to express the accuracy of generalized methods of computing the isothermal effect of pressure on enthalpy in terms of enthalpy units. This will be done in the next chapter. The comparisons on mixtures do not indicate anything definite about the use of the psuedo-critical.

Other experimental Joule-Thomson coefficients are reported by Pattee and Brown[9] for *n*-pentane and a paraffin naphtha, by Lindsay and Brown[8] for benzene, and by Konz and Brown[7] for *n*-pentane. These three investigations were made on the same apparatus, which included a calorimetric condenser to measure the enthalpy value of the isenthalps. The *n*-pentane in the Pattee-Brown article was only 94 percent pure but Konz-Brown used 99+ percent pure *n*-pentane. Pressure-temperature plots with constant enthalpy lines were prepared for these substances. Benzene isenthalps were drawn straight. Comparisons of calculated with these observed observed values of the Joule-Thomson coefficients will not be made because the experimental data are not in a form giving point values of μ. Values of μ could be readily obtained by plotting, however.

TABLE 28
Compositions and pseudo-criticals for natural gases[14]

Components	Gas A	Gas B
Composition	Mol Fraction	Mol Fraction
Carbon Dioxide	0.0090	0.0420
Methane	0.8255	0.8385
Ethane	0.0901	0.0637
Propane	0.0462	0.0374
Isobutane	0.0074	0.0039
n-Butane	0.0126	0.0095
Isopentane	0.0032	0.0016
n-Pentane	0.0022	0.0011
Hexanes plus	0.0038	0.0023
Total	1.000	1.000
Pseudo-Critical:		
T_{pc} °R.	393	384
P_{pc} psia.	682	687

TABLE 29
Joule-Thomson coefficients for two natural gases

Temp. °F.	Pressure, psia.	μ, °F./psia. Gas A obs.[14]	Gas A Calc.	Gas B obs.[14]	Gas B Calc.
70	200	0.0697	0.0709	0.0659	0.0676
	400	0.0701	0.0700	0.0659	0.0654
	500	0.0698	0.0676	.....	.....
	600	.....	.....	0.0655	0.0658
190	200	0.0458	0.0438	0.0423	0.0420
	400	0.0464	0.0425	0.0419	0.0400
	500	0.0461	0.0420	.....	.....
	600	.....	.....	0.0407	0.0398
310	200	0.0284	0.0296	0.0263	0.0284
	400	0.0287	0.0284	0.0263	0.0274
	500	0.0286	0.0278	.....	.....
	600	.....	.....	0.0261	0.0258

TABLE 26
Joule-Thomson Coefficients for Methane-Propane Mixtures

Temperature °F.	Pressure, psia.	24.48 Wt. % Propane T_{pc} = 378° R., P_{pc} = 667 psia. μ, °F./psia. obs.[1]	Calc.	50.66 Wt. % Propane T_{pc} = 426° R., P_{pc} = 658 psia. μ, °F./psia. obs.[1]	Calc.	75.42 Wt. % Propane T_{pc} = 515° R., P_{pc} = 644 psia. μ, °F./psia. obs.[1]	Calc.
70	200	0.0694	0.0658	0.0939	0.0884	0.143	0.131
	600	0.0691	0.0611	0.0905	0.0806	.....	.....
160	200	0.0477	0.0456	0.0634	0.0575	0.0944	0.0860
	400	0.0482	0.0455	0.0634	0.0561	0.0991	0.0860
	600	0.0479	0.0424	0.0619	0.0549	0.0994	0.0836
	1000	0.0446	0.0399	0.0552	0.0514	0.0953	0.0827
	1500	0.0389	0.0342	0.0438	0.0445	0.0827	0.0790
220	200	0.0385	0.0372	0.0501	0.0461	0.0706	0.0641
	400	0.0390	0.0364	0.0504	0.0450	0.0726	0.0632
	600	0.0384	0.0345	0.0496	0.0432	0.0732	0.0626
	1000	0.0352	0.0318	0.0461	0.0403	0.0678	0.0611
	1500	0.0302	0.0274	0.0388	0.0360	0.0514	0.0508
280	200	0.0311	0.0312	0.0399	0.0368	0.0543	0.0509
	400	0.0316	0.0300	0.0401	0.0359	0.0557	0.0498
	600	0.0310	0.0289	0.0397	0.0349	0.0541	0.0493
	1000	0.0285	0.0263	0.0374	0.0323	0.0551	0.0472
	1500	0.0241	0.0224	0.0320	0.0282	0.0502	0.0417

TABLE 27
Joule-Thomson Coefficients for Methane-nButane Mixtures

Temperature °F.	Pressure, psia.	10 Wt. % n-Butane T_{pc} = 356.8° R., P_{pc} = 670.1 psia. μ, °F./psia. obs.[4]	Calc.	30 Wt. % n-Butane T_{pc} = 388.3 °R., P_{pc} = 650.8 psia. μ, °F./psia. obs.[4]	Calc.	50 Wt. % n-Butane T_{pc} = 435.5° R., P_{pc} = 616 psia. μ, °F./psia. obs.[4]	Calc.
70	250	0.0546	0.0585	0.0668	0.0679	.....	.....
	500	0.0549	0.0555	.....	.....	.....	.....
	1000	0.0505	0.0511	.....	.....	.....	.....
	1500	0.0414	0.0438	.....	.....	.....	.....
190	250	0.0342	0.0376	0.0414	0.0415	0.0534	0.0505
	500	0.0345	0.0359	0.0417	0.0399	0.0536	0.0494
	750	0.0336	0.0338	0.0408	0.0381	0.0525	0.0479
	1000	0.0320	0.0318	0.0385	0.0366	0.0506	0.0463
	1250	0.0296	0.0298	0.0358	0.0354	0.0478	0.0430
	1500	0.0271	0.0276	0.0327	0.0350	0.0442	0.0399
310	250	0.0208	0.0258	0.0266	0.0275	0.0340	0.0336
	500	0.0210	0.0239	0.0268	0.0263	0.0343	0.0325
	750	0.0203	0.0223	0.0261	0.0249	0.0334	0.0304
	1000	0.0193	0.0212	0.0249	0.0238	0.0324	0.0290
	1250	0.0182	0.0196	0.0234	0.0222	0.0305	0.0274
	1500	0.0170	0.0181	0.0218	0.0202	0.0282	0.0251

Conclusions

A useful generalized method of estimating Joule-Thomson coefficients is presented and demonstrated for five pure hydrocarbons and eleven hydrocarbon mixtures. The average deviation of this method is 7 percent for pure components and mixtures. Considering the facts that three separate functions are involved in calculating Joule-Thomson coefficients and that two of these are generalized, this agreement is not bad.

In the next installment generalized correlations will be presented for the isothermal effect of pressure on the entropy and enthalpy and values of the isothermal pressure correction to the enthalpy from the sources used and mentioned in this chapter plus other data will be compared with the calculated by generalized correlations.

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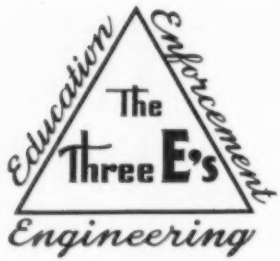


Enforcement For Safety

F. J. SLUZE
Safety Director, Ashland Oil & Refining Company
Ashland, Kentucky

THIS article, the caster oil of the "Three E's of Safety," is the most distasteful and unpleasant to swallow. *Education* of employes for safety has always been a pleasant and popular approach to accident prevention since it extends acceptable service to workers. *Engineering* likewise is a quiet, businesslike, and non-controversial approach to the goal of accident prevention. *Enforcement* which involves discipline of workers conjures in the mind punishment, penalty, and hardship which workers resent inwardly and in some cases outwardly. This is not the intent of proper discipline.

To make enforcement acceptable to the majority of workers it will be necessary to change the whole mental structure, attitude and behavior of this majority of workers.

Looking back into the dark ages of employer and employe relations when the owner was absolute boss and ruled his working force with an iron hand, there is small wonder that the natural reaction of a worker is to protect his fellow man against any attempt by management to control the behavior of workers. But that relationship between management and worker has undergone a decided change for the better, and the time has arrived for workers' attitudes to also change and forget the past.

Suppose that you were surprised late at night by a thief trying to enter your bedroom window. What would you do? It is very likely that you would grab him and hold him down on the floor until your wife called a police officer to have the culprit arrested. You learned long ago that this is the proper thing to do with law violators. But did anyone ever hear of a worker grabbing a law violator in the plant and sending a fellow worker for the supervisor to have the violator brought ot justice? Of course not. The time is not yet ripe to brand a violator of plant rules anti-social as the thief is branded in everyday society.

***ENFORCEMENT** is the castor oil of the "Three E's of Safety," but is, of course, quite essential if a safety program is to work. Violators of plant rules must be apprehended, but before this can be carried out the rules themselves have to be laid down so that all workers can understand and be guided thereby. Firm, although not harsh, enforcement is recommended among other things in this, another article, by the same author who wrote on "Engineering for Safety" in the October, 1948, REFINER.*

Before enforcement can be applied in the accident prevention program, it will be necessary for leaders in industry to do considerable spade work so that workers will subscribe to and adhere to such a program. They will have to be sold on the idea that any person violating plant rules is anti-social and a menace to plant society.

The next step, if this has not already been done, is to provide the necessary legislation so that violators of plant rules can be apprehended. Everyone in the plant must be trained to understand what is compliance and what constitutes a violation and how such violations effect their well being.

Such legislation must be contributed and agreed upon by a majority of the workers if we are to expect their adherence. This legislation must be fair, direct, brief and to the point, and free from any misunderstanding. There should be no doubt as to everyone's responsibility. Once the rules have been agreed upon, they should be published in booklet form and each worker provided with a copy of the rules.

If enforcement is to perform its accident prevention function, disciplinary measures will have to be established. This disciplinary system must be firm, impartial but not harsh. As in our courts, all facts must be gathered and weighed and then a just verdict

arrived at. When the verdict has been rendered, a just penalty must be meted out.

Felonies and Misdemeanors

In law there are two chief types of law violation—a felony and a misdemeanor. A felony, as is commonly defined, is a crime punishable by death or imprisonment in a state prison. A misdemeanor is an offense of a less atrocious nature than a felony and applies to offenses inferior to a felony.

Carrying these interpretations into plant work, we find that violations comparable to a felony are:

Smoking in forbidden places
Provoking a fight inside the plant
Coming into the plant intoxicated
Gambling within the plant
Stealing
Sleeping on the job
Deliberately wrecking equipment or property
Deliberately endangering life and limb of workers.

These violations should carry the same penalty in the plant as they do in society, namely, payroll death or discharge from duty.

Misdemeanors are less atrocious violations or everyday rule violations such as:

Horseplay
Failure to wear goggles where required
Failure to lash or secure ladders
Failure to wear safety belts or harness where required
Failure to get first aid where required.

A scale of penalties should be established for these violations. Three stages of penalties most commonly used in industry are:

First offense—reprimand or corrective explanation
Second offense—suspension from duty without pay
Third offense—the penalty for a repeater or habitual violator—discharge from duty.

Written Record Suggested

The person meting out a penalty for habitual violations must have positive proof of these violations, and the only proof that will be recognized is written records at the time of such violations. Trusting to memory will not be accepted by any authority sitting in judgment should the person affected take an appeal against the penalty.

Principles outlined in this article do not indicate present practices in any plant but are designed to attack the problem of enforcement for safety in a practical and realistic manner.

Readers will question what can be done about the obstructive headaches usually encountered in attempts at enforcement.

A safety engineer in a plant in West Virginia appears to have found a solution to this problem. His plant wasn't getting anywhere with enforcement until he revised his program. According to him, they organized a three-man safety committee consisting of a supervisor, a union representative, and the safety engineer himself. The safety engineer voted only in case of a deadlock. The first thing that this committee did was to review accident prevention efforts as practiced in the past and the results attained. They learned from this review that enforcement, one of the "Three E's" was not functioning. The triumvirate then agreed to take over enforcement and put it on a sincere and business-like basis. In the course of time a few cases developed where positive action regarding penalties became necessary. When such cases were thoroughly studied and reviewed, the committee agreed unanimously that the violations justified a suitable penalty, and the appropriate penalty was meted out.

The philosophy of good government in a plant or in society is best exemplified by a Chinese proverb which says, "Govern a great nation as you would cook a small fish"—don't overdo it.

Proper training of workers, consistently maintained, will relegate enforcement to a minor role in the "Three E's" of accident prevention.

The above cartoons as well as the one on the opposite page are reproductions of posters offered by the National Safety Council, 20 N. Wacker Drive, Chicago, and used through its courtesy.

* * *

REFINER AUTHORS and Other Personalities

Corrosion Resistance Masonry His Topic

TINKERING with problems related to chemical process and equipment design is a pleasure for Ernest E. Ludwig, author of the article, "Corrosion-Resistant Masonry Construction for Chemical Process Industries" (starts on page 79). Music also rates high and while in high school, he won several medals in state and national competition for solo, duet and trio cornet playing. Ludwig continued his music at the University of Texas, playing with the Longhorn band.

Both his bachelor of science and his master of science in chemical engineering were received from the University of Texas. While attending the university he was an instructor in chemistry and a student assistant in engineering drawing.

In 1942 Ludwig joined the Texas division of Dow Chemical Company as a chemical engineer. Four years later he was placed in charge of the Houston engineering office of the company. When this office was discontinued in 1947, he returned to Freeport. At present he is section engineer handling process design and development as assistant to the assistant engineering manager.

During the war Ludwig brushed up on his classroom technique and taught several night classes at Freeport for the E.S.M.W.T. program. He is a member of the American Chemical Society, Texas Dow Institute, the American Institute of Chemical Engineers and is a registered professional engineer in the State of Texas. Photography, fishing and gardening are other hobbies that claim a portion of Ludwig's time.

E. E. LUDWIG

Rugh and Mattocks Are LPG Experts

K. W. RUGH and Elmer O. Mattocks, Phillips Petroleum Company, present "Liquefied Petroleum Gas Sales Continue Gains in 1948," to the REFINER's economic pages. It begins on page 159.

These men, well qualified to write on this topic, point out many interesting facts about the LPG marketing. It is something of a surprise to hear that sales in 1948 were nearly 30 per cent higher than the preceding year and that this increase in 1948 over 1947 is greater than the total quantity of LPG marketed in 1942. Also, nearly one-fourth of the total LPG marketed since 1930 was sold in 1948. This article can be recommended as a thorough and comprehensive discussion of the LPG market by two men who are posting the scoreboard.

It appears that the parents of K. W. Rugh, who is manager of the Philgas division of the sales department of Phillips, took the "Go West" advice, stopping in Greeley, Colo., Rugh's birthplace. So, for the early years of his life, Rugh roamed the hills and valleys of beautiful Colorado.

When time for work came along, he attended the University of Illinois, where he was graduated in commerce and business administration. In June, 1930, he joined Phillips, where he has been engaged in LPG marketing continuously.

Rugh has been active in the Liquefied Petroleum Gas Association since its organization. He is a member of its board of directors and has been chairman of the legislative committee for several years.

The Rugh family includes two children—young Rugh, age 9, and little Miss Rugh, age 4. When Rugh disclosed his hobby, it caused a chorus of "of course." The hobby is hunting, a natural for a native of Colorado.

Elmer O. Mattocks, stocky, genial technical representative of the chemical engineering department of Phillips, is widely known throughout the natural gasoline-LPG industry. He was born in Elmira, N. Y., where he attended elementary and high school. Mattocks is a Cornell University graduate in mechanical engineering; also a member of Phi Kappa Phi fraternity.

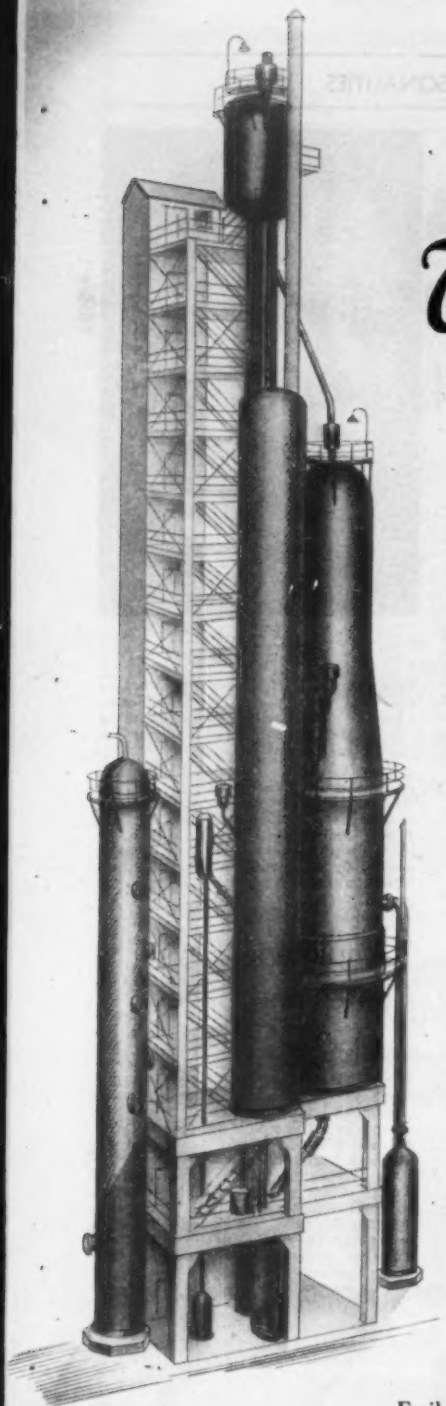
Mattocks used up 11 years in the east before he came to Oklahoma with Phillips. He spent five years with the Syracuse Lighting Company in Syracuse, N. Y. (now Central New York Power Corporation), six years with the American Gas Association Testing Laboratories in Cleveland, Ohio, and then joined Phillips as an industrial engineer.

He is active on various committees of the American Gas Association, American Petroleum Institute, American Society for Mechanical Engineers, American Society for Testing Materials, Compressed Gas Manufacturers Association, Liquefied Petroleum Gas Association, National Fire Protection Association, and Natural Gasoline of America.

Mattocks did not disclose a hobby in the notes made for this sketch, but he is the proud father of three daughters, ages 4, 14, and 19.

K. W. RUGH

E. O. MATTOCKS



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J. F. CHURCHILL

Pair from Drew On pH Control

DR. R. C. ULMER and J. F. Churchill, E. F. Drew & Company, Inc., are the authors of the paper, "pH Control Through the Use of a Sulfur Burner—Elimination of Scale and Prevention of Delignification in Cooling Towers and Similar Equipment," which begins on page 120 of this issue. The paper was originally presented before the California Natural Gasoline Association in Los Angeles.

Dr. Ulmer is the technical director of the power chemicals division of the company in New York. His experience has been wide and varied in the field of chemistry, especially that concerned with power plants. He received his A.B. degree from Ohio State University, and was then employed by Columbus & Southern Ohio Electric Company in 1930. With the aid of a fellowship at Ohio State University he obtained his Ph.D., after which he joined Detroit Edison Company. In the chemical division of the research department of this company, he was concerned with the diverse problems involved in the operation of power plants. He joined E. F. Drew & Company as technical director in 1945, in charge of all water treating problems and research and development of water treating products for that company.

The author of numerous technical papers, Dr. Ulmer holds membership in the National American Chemical Society and the Chemists Club of New York, American Society for Testing Materials, American Society of Mechanical Engineers and the National Association of Power Engineers.

Dr. Ulmer is married, has a 6-year-old daughter and admits that "my interests sort of center around her." His chief hobby is photography, especially motion pictures, and he gets out for a golf game now and then.

J. F. Churchill is West Coast manager in San Francisco for the American Colloid Division of the E. F. Drew & Company. He attended the University of Pennsylvania and University of Southern California and has been connected with the natural gas industry in California since 1925. Besides being very well known throughout the industry, he is well acquainted with the water problems faced by the plants. Churchill has worked on a number of problems with Dr. Ulmer, one of which is the sulphur burner described in their current paper.

Something New In Compressors

W. R. BARRETT was born on a small farm near Carthage, Mo., in 1888. For the past seven years, he has been superintendent of the mechanical maintenance section of the gasoline department of Phillips Petroleum Company. This new piston development, described in his article, "Operating Flexibility for Process Gas Compressors," represents a large progress step from his first job as blacksmith's helper in the lead and zinc mining operations near Joplin, Mo., but a fellow has to make a start somewhere. The article starts on page 93. Barrett installed some of the first gas engines and gas-engine driven compressors in the Joplin area, so that the subject of engines and compressors is by no means a stranger to him.

When World War I came along, Barrett served 15 months overseas with the U. S. 16th Engineers.

He joined Phillips after the war, and it was he who installed the compressors in the first absorption gasoline plant at Pershing, Okla. His pioneering work in this field took him to Central Texas, where he met a young lady also from the "Show Me" State of Missouri. She became Mrs. Barrett.

Barrett has a 16-year-old son currently attending high school in Bartlesville, Okla. When not tinkering with a new idea for an old compressor, or with a new compressor to make it run, he likes to turn them over to automatic control by an operator and indulge in a little hunting or fishing, according to the season.

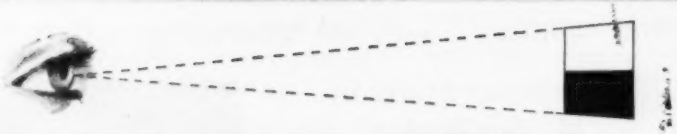
W. R. BARRETT

R. C. ULMER

"Simplified," Says Coates and Bailey

JESSE Coates and Raymond V. Bailey, hard-working Pelican State University (LSU) faculty men, have returned from several weeks of deep seclusion (a combined hunting-fishing trip into the swamp is suspected) and present Part I of their latest article for readers of the REFINER beginning on page 106 of this issue. "Simplified Multi-Component Fractionation Calculations—Distribution of Split Key Components" is the title of their article. It will be published in two parts. They have authored other discussions under the same general title, these appearing in the January, February, March and October, 1948, issues of PETROLEUM REFINER.

Coates is a graduate of LSU (1928) in chemical engineering, receiving his master's degree and Ph.D. from the University of Michigan in 1932 and 1936, respectively. Now he is professor of chemical engineering at the university in his home town of Baton Rouge. He has been teaching and working as a consultant since 1936. Currently, he handles the toughest courses in chemical engi-



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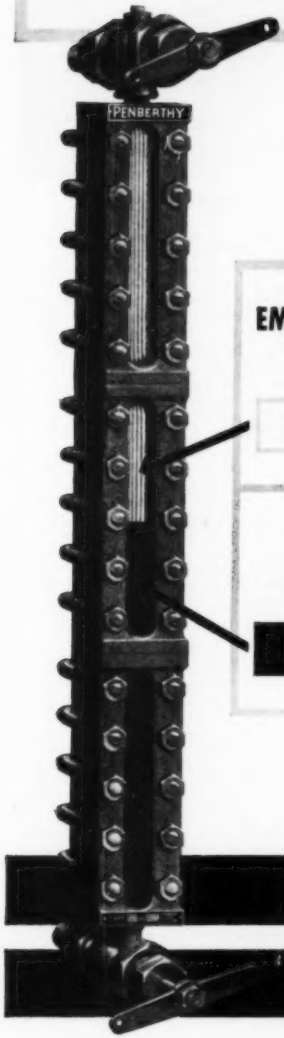

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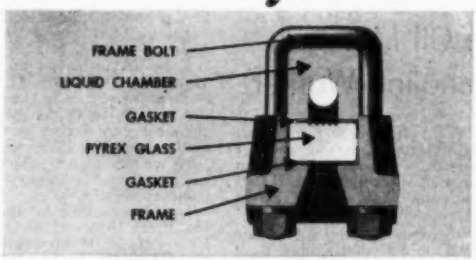

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J. E. WHITE

neering offered by the university, including plant design, thermodynamics, and advanced unit operations. He is directing research in the fields of fluid flow, heat flow, distillation, and liquid-liquid extraction.

Bailey is a graduate student at LSU and a graduate assistant in chemical engineering since 1946. He was graduated (cum laude) from Louisiana Polytechnic Institute in 1944. He has worked for Cities Service Refining Corporation and in the 6th Army Regional Laboratory at Presidio of Monterey, Calif. Bailey is devoted to mathematics—simplified calculations, empirical equations and nomography, but he is by no means adverse to slipping quietly from the lab with Coates with rod and reel or gun for fishing and hunting.

Crude Oil Metering By Stanolind Worker

J. E. WHITE, who prepared the paper "Crude Oil Metering," starting on page 113 of this issue of REFINER, writes that he is a native of Shreveport, La. He attended Louisiana State University at Baton Rouge.

After graduation, White joined Lago Oil and Transport Company and went to Aruba, Netherlands West Indies, in the instrument engineering and maintenance department. Returning to the United States, he engaged in instrument engineering in Dallas. For the past two years, he has been with Stanolind Oil & Gas Company in Tulsa.

White lists his occupational hobbies as instrument design and development. His two sons, Mike and Terry, and photography get along pretty well together. He plays golf, hunts, and likes to follow football—especially the SMU Mustangs.

Another Study by M. Van Winkle

MATTHEW Van Winkle, associate professor of chemical engineering at the University of Texas, authored the article, "Pressure-Temperature Correlations for Petroleums and Hydrocarbons" (starts page 88) for this issue of REFINER. Van Winkle's last appearance in the REFINER was in the June, July and August, 1948, issues of PETROLEUM REFINER with his treatment of "Thermal Properties of Petroleum Oils."

Well-known in the chemical engineering field, Van Winkle is the author of the book, *Aviation Gasoline Manufacture*. He received his chemical engineering degree from Purdue University in 1933, and since that time has been associated with Cities Service Oil Company, Standard Oil Company (Indiana), Pennsylvania State College, and the University of Michigan. He was awarded a master's degree in chemical engineering by the University of Michigan in 1945.

Contribution from University of Texas

KENNETH Albert Kobe, graduate professor of chemical engineering, University of Texas, Austin, has turned out "Thermochemistry for the Petrochemical Industry." The first installment of the series begins on page 83 in this issue. The series is the result of a great deal of effort to collect all the available heat capacity and enthalpy data on important gases and vapors, evaluate them critically, select the most reliable, and present them in the most readily usable forms of curves and charts.

Experience In Industry

The article is typical of the thoroughness and capability of a chemical engineer possessing the background of experience in industry and teaching held by Kobe.

Kobe first attended the University of Minnesota, 1922-30. He received his bachelor of science in chemical engineering in 1926 (with distinction); M.S. in chemical engineering and a minor in mathematics in 1928, and a Ph.D. in 1930 with a major subject of physical chemistry and a minor subject of organic chemistry.

In the meantime he turned to teaching. From 1926 to 1930 he taught at the University of Minnesota and from 1931 to 1941 at the University of Washington. Since then he has been at the University of Texas.

Kobe served as captain during the war from July, 1942, to January, 1943, then as major until March, 1944. He was an instructor at the chemical warfare school for nine months.

Holds Patent

In 1926 Kobe worked part time for Bradley-Fitch Company on the recovery of manganese from low-grade iron ores in Minnesota. He was granted a patent on what is now the company's approved process. He worked for Du Pont Ammonia Corporation and then National Safe Protector Company, where he obtained a patent on a lachrymatory corporation, which is CNS of the Chemical Corps.

KENNETH A. KOBE

He has been an industrial consultant since 1931. He was retained for three years by Manganese Products, Inc., as technical director for three years. Kobe is a registered professional engineer in Texas.

He has engaged in the direction of projects on research and development in the chemical engineering field and technology since 1931, except during his military service. During this time, 139 theses for the B.S., M.S., and Ph.D. degrees have been done under his direction. He has 12 graduate students working under his direction at present.

Doing Research

Kobe is associate director, Bureau of Industrial Chemistry, University of Texas, which is engaged in research on Texas' natural resources.

Kobe is listed in *Who's Who in America*, *Who's Who in Engineering*, and *American Men of Science*. Also, he is a member of American Institute of Chemical Engineers, American Chemical Society, Sigma Xi, Tau Beta Pi, Phi Lambda Epsilon, Omega Chi Epsilon, Gamma Alpha, and Alpha Chi Sigma. He is associate editor, Journal of Chemical Education, and editorial adviser on chemical engineering and industrial chemistry, Macmillan Company.

He has written *Inorganic Process Industries*, 1948, Macmillan Company, and *Chemical Engineering Reports*, 1947, Second Edition. In addition, he has more than 110 publications, including five patents in scientific, technical, and trade publications.

ONE major responsibility of this organization is to convert results of laboratory research and pilot plant operations into *profitable* refining facilities.

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DESIGN, ENGINEERING AND CONSTRUCTION

FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION

Refinery and Other Plant Construction

Companies whose projects are not listed or readers who know of unlisted projects are urged to: 1) send in data on units not shown herein; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work. Such cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Esso Standard Oil	Linden, N.J.	Vac. pipe still	40,000 bbls.		Under Constr.	1st Qtr., 1949		S.O.D. & Braun	Braun
Esso Standard Oil	Linden, N.J.	Cat. Crack, Light Ends	41,000 bbls.		Under Constr.	2nd Qtr., 1949		S.O.D., Braun	Braun
Esso Standard Oil	Bayonne, N.J.	Dewaxing	7,500 bbls.		Under Constr.	1st Qtr., 1950	Texaco	Badger	Badger
Gulf Oil Corp.	Philadelphia, Pa.	Topping and Vacuum Unit	30,000 bbls.		Under Constr.	Sept., 1949		Lummus Badger	Lummus
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Dist. Unit	20,000 bbls.		Under Constr.	Mid 1949		Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Propane Deasphalting	6,600 bbls.		Under Constr.	Mid 1949	Juik	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Furfural Refg.	4,450 bbls.		Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	MEK Dewaxing	2,050 bbls.		Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Clay Contact Unit			Designing	Late, 1949		Badger	Badger
*Socony-Vacuum Oil Co., Inc	Paulsboro, N.J.	Light Oil Treating Plant	27,000 bbls.		Designing	Mid 1949		Badger	Badger
L. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Acid Plant, Anti-Pollution		$400,000	Under Constr.	1949		Chemical Constr. Co.	Morris Knowles & Co.
Sun Oil Co.	Marcus Hook, Pa.	Wax			Under Constr.	1949	Texaco	Staff	Staff
Sun Oil Co.	Marcus Hook	Comp. & Pkg.			Under Constr.	1949		Staff—Lindsay	W. W. Lindsay
The Texas Co.	Beacon, N.Y.	Expand Research Labs.			Under Constr.	Oct., 1, 1949		Voorhees, Walker, Foley & Smith	
The Texas Co.	Westville, N.J.	New Refinery	40,000 bbls.		Under Constr.	July, 1949		Foster-Wheeler, Jackson-Moreland, Kellogg	Foster-Wheeler, Kellogg
Tide Water Associated Oil Co.	Bayonne, N.J.	Revamping Houdry Fixed Bed Unit			Under Constr.		Houdry	Houdry	Cat. Constr.
U. S. Dept. of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant (Coal-to-gasoline synthesis)	1-2 bbls.	$150,000	Under Constr.	June, 1949		Staff	Blaw-Knox Co.
MID-CONTINENT									
Ashland Oil and Refining Co.	Ashland, Ky.	Revision & Modernization of Refg. Units		$500,000	Under Constr.	Jan., 1949		Staff	Staff
Barco Oil Co.	Wichita, Kans.	LPG	250 bbls.	$100,000		Completed		Born	Born
Berry Asphalt Co.	Stephens, Ark.	Expand Asphalt Plant	2,000 bbls.			Completed		Staff	Staff
Berry Asphalt Co.	Waterloo, Ark.	Lube Unit, Expand Asphalt Facilities	1,200 bbls.			Completed		Process Eng.	Process Eng.
Cities Service Oil Co.	Chicago	Compounding & Grease Plant	1,500 bbls.	$2.5 million	Design	Late 1949		Sumner-Sollitt	
Cities Service Oil Co. (Delaware)	E. Chicago, Ill.	Modernize Plant		$18 million		Completed	Kellogg	Kellogg	Kellogg
Cooperative Refinery Association	Coffeyville, Kansas	Dewaxing	2,200 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
Continental Oil Co.	Ponca City, Oklahoma	Repair & Revision to Cat. Crackers	22,500 bbls.	$944,000	Under Constr.	Jan., 1949	Houdry	Cat. Constr.	Cat. Constr.
Continental Oil Co.	Ponca City, Okla.	Crude Topping	†30,000 bbls.		Projected	Mid 1950			
Continental Oil Co.	Ponca City, Okla.	Modernize TCC		$1 million	Projected	Mid 1950			
*Continental Oil Co.	Ponca City, Oklahoma	Crude Dist. Unit	30,000 bbls.		Under Constr.	Oct., 1949		Bechtel	Bechtel
Dewese Oil Co.	Weston, Ohio	Lube Filtering Unit, Desalting	250 bbls.	$15,000	Under Constr.	Spring, 1949		Staff	Staff
The Globe Oil & Refining Co.	Lemont, Ill.	Cat Cracker Unit	6,000 bbls.		Buying Material	Jan. 1, 1950	U.O.P.	U.O.P.	
Gulf Refg. Co.	Toledo, Ohio	Top & Vac. Unit	32,000 bbls.		Under Constr.	Feb., 1949		Badger	Badger
Gulf Refg. Co.	Toledo, Ohio	Fluid Cat. Crk.	15,500 bbls.		Under Constr.	May, 1949		Kellogg	Kellogg
Gulf Refg. Co.	Toledo, Ohio	Poly Unit	5,000 bbls.		Under Constr.	May, 1949	U.O.P.	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Fluid Unit	15,500 bbls.		Under Constr.	June, 1949		Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Polymer Plant	5,000 bbls.		Under Constr.	June, 1949	U.O.P.	Kellogg	Kellogg
Hiwan Oil Co.	Magnolia, Ark.	Gasoline Plant	10,000 mcf		Part Completed			Petro. Eng.	Petro. Eng.
Kanotex Refg. Co.	Arkansas City, Kansas	Cat Cracking	4,200 bbls.	$500,000		Completed	Phillips	Koch Eng.	Koch Eng.
Lion Oil Co.	El Dorado, Ark.	Enlarge Ammonia Unit	570 tons	$3.5 million	Under Constr.	June, 1949		Chem. Constr.	Chem. Constr.
Lion Oil Co.	El Dorado, Ark.	Protective Coating Plant	100 tons	$250,000		Completed	Staff	Staff	Staff
Lion Oil Co.	El Dorado, Ark.	Sulfuric Acid Plant	300 tons	$1¼ million	Under Constr.	Sept., 1949		Chem. Constr.	Chem. Constr.
Lion Oil Co.	El Dorado, Ark.	Ammonium Sulfate Plant	380 tons	$750,000	Under Constr.	Sept., 1949		Chem. Constr.	Chem. Constr., Blaw-Knox
M. F. A. Oil Co.	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	Under Constr.	Jan., 1949	Phillips	Koch	Staff
Magnolia Pet. Co.	Grant County, Kans. (Hickok)	Gasoline Plant	100,000 mcf		Design	Oct., 1949			
Magnolia Pet. Co.	Grady County, Oklahoma	Gasoline Plant	30,000 mcf		Design	Sept., 1949			
Magnolia Petroleum Co.	Stephens County, Okla.	Gasoline Plant	30,000 mcf		Design				
Mercury Oil Refining Co.	Oklahoma City, Oklahoma	Crude Unit	3,500 bbls.	$250,000	Under Constr.	Dec., 1949		Ref. Eng.	Ref. Eng.
Midland Cooperative Wholesale	Cushing, Okla.	Thermal Reforming	1,400 bbls.	$300,000	Under Constr.	March, 1949	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
Ohio Oil Co.	Robinson, Ill.	Vac. Unit Cat. Crack, Crude Still, Poly, LP G Recovery	27,500 bbls.	$15 million	Under Constr.	Early, 1949	U.O.P.	McKee	McKee, Pritchard
Old Dutch Refg. Co.	Muskegon, Mich.	LPG Recovery	3,400 gallons	$45,000		Completed	U.O.P.	Staff	Staff
Old Dutch Refg. Co.	Muskegon, Mich.	Crack Plant Revamp	800 bbls.	$30,000		Completed	U.O.P.	Staff	Staff
Peteo Corp.	Blue Island, Ill.	Cat. Cracker Unit, LPG Recovery System	5,000 bbls.	$400,000	Under Constr.		Houdry		Clark's

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Petroleum Specialties, Inc.	Flat Rock, Mich.	Increasing distillation, and other Plant Facilities	6,000 bbls.	$50,000	.....	Completed	.....	Staff	Staff
Phillips Pet. Co....	Kansas City, Kansas	Lubricating Unit	1,500 bbls.	.....	.....	Completed	.....	Kellogg	Kellogg
Phillips Pet. Co....	Ditto	Cat. Crack	24,000 bbls.	.....	Under Constr.	Oct., 1949	.....	Braun	Braun
Phillips Pet. Co....	Ditto	Cat. Poly	1,500 bbls.	.....	Under Constr.	Oct., 1949	.....	Braun	Braun
Phillips Pet. Co....	Guymon, Okla.	Absorption Plant	173,000 mcf	.....	Authorized	July, 1949	.....	.....	.....
Rock Island Refg. Corp.	Rock Island, Ind.	Fluid Cat, Crk	10,000 bbls.	$1,300,000	Contracted	July, 1949	U.O.P.	U.O.P.	Staff
The Shallow Water Refining Co.	Shallow Water, Kansas	Reforming Unit	1,250 bbls.	$85,000	Materials Ordered	Fall, 1949	Pereo	Koch Eng.	Koch Eng.
Sinclair Refg. Co....	E. Chicago, Ill.	Crude, Cat. Cracker, Poly Plant & Lube Treating	55,000 bbls.	.....	.....	Completed	Texaco (dewax)	Lummus, Braun, Sinclair	Braun, Lummus
Skelly Oil Co.....	Eldorado, Kans.	Crude Dist. Unit, Cat. Crk.	35,000 bbls.	.....	Under Constr.	Mid 1950	.....	.....	.....
Socony-Vacuum....	E. St. Louis, Ill.	Crude, Thermal Crack, Coke	.....	.....	Under Constr.	Oct., 1949	.....	Bechtel Corp.	Bechtel Corp.
Standard Oil Co., (Indiana)	Whiting, Ind.	Motor Oils Unit	.....	.....	.....	Completed	.....	.....	Foster-Wheeler, Stone & Webster
Standard Oil Co., (Ohio)	Lima, Ohio	Lube Oil Solvent, Refining Plant	76,000 gals.	$13 million	Contracted	1951	.....	Kellogg, Lummus	Kellogg, Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Cat Cracking	16,000 bbls.	$11 million	Under Constr.	Late 1949	U.O.P.	McKee	McKee
Standard Oil Co., (Ohio)	Lima, Ohio	Crude Distl., Coke	†15,000 bbls.	$5 million	Authorized	Mid 1950	Kellogg	Kellogg	Kellogg
Standard Oil Co., (Ohio)	Lima, Ohio	Solvent Extraction Dewaxing Unit	1,800 bbls. Finished Products	.....	Authorized	Mid 1950	Texaco	.....	Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Vacuum Unit	9,000 bbls.	.....	Authorized	Mid 1950	.....	.....	Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Propane Deasphalting Unit	800 bbls.	.....	Authorized	Mid 1950	.....	.....	Lummus
Stanolind O&G Co.	Ulysses, Kans.	Gasoline Plant	100,000 mcf	.....	Under Constr.	April 1, 1949	.....	J & L Constr.	J & L Constr.
Sun Oil Co.....	Toledo, Ohio	Cat. Crack Crude Dist., Vac., Poly	30,000 bbls.	$16 million	Under Constr.	1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil Co.....	Toledo, Ohio	Anti-Pollution	600,000	.....	Under Constr.	1949	.....	Sun Oil	Cat. Constr.
The Texas Co.....	W. Tulsa, Okla.	Crude and Cat. Cracking	30,000 bbls.	.....	Under Constr.	July. 1, 1949	.....	Kellogg, Foster-Wheeler, U.O.P.	Kellogg, Foster-Wheeler
The Texas Co.....	Lawrenceville, Illinois	Expand Refinery	†20,000 bbls.	.....	Proposed	Jan. 1, 1951	.....	.....	.....
Tide Water Associated Oil Co.	Drumwright, Oklahoma	Houdriflow Unit Cat. Cracker	4,800 bbls.	.....	Contracted	.....	Houdry	.....	Process Eng.
U. S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	75 bbls.	$4.4 million	Under Constr.	Oct., 1949	.....	Koppers	Koppers
Warren Pet. Corp.	Madill, Okla.	Gaso. Plant Enlargement	25,000 bbls.	.....	Under Constr.	Feb. 15, 1949	.....	Hudson	Hudson
Warren Pet. Corp.	Maysville, Okla.	Gasoline Plant	8,000 bbls.	.....	Under Constr.	Mar. 15, 1949	.....	Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Ill.	Cat. Cracking Gasoil Cracking	8,500 bbls.	$1 million	Under Constr.	Jan., 1949	Phillips	Koch Eng.	Koch Eng.
SOUTHWEST									
Alamo Refg. Co....	Sweeny, Texas	LPG Fract.	.....	.....	.....	Completed	.....	.....	.....
Amarillo Oil Co....	Amarillo, Texas	Gas Compressor Dehydration	70 mcf	.....	.....	Completed	.....	.....	Blaw-Knox Co.
The Atlantic Refining Co.	Port Arthur, Texas	Increase Capacity	42,300 bbls.	.....	.....	Completed	.....	Staff	Staff
*The Atlantic Refining Co.	Block 31, Crane County, Texas	Gas Injection Plant	8,320 mcf	.....	Under Constr.	May, 1949	.....	Hudson, Staff	Hudson
Barnsdall Oil Co...	West Tepetate Field, La.	Gasoline Plant	20,000 mcf	$800,000	Under Constr.	Middle 1949	.....	Dresser	Dresser
*Barnsdall Oil Co...	McFadden Field, Texas	Gas Compressor Plant	7,000 mcf	.....	Under Constr.	Feb., 1949	.....	Olsen	Olsen
The California Co.	Hico, La.	Gasoline Plant	70,000 mcf	.....	.....	Completed	.....	Hudson	Hudson
The California Co.	Brookhaven, Mississippi	Cycling Plant	10,000 mcf	.....	Designing	3rd quarter, 1949	.....	Hudson	Hudson
Calumet Refg. Co..	Princeton, La.	Modernization of Lube Plant	700 bbls.	.....	.....	Completed	.....	Staff	Staff
Carthage Corp.....	Carthage, Field	Gasoline Plant	250,000 mcf	$3.5 million	Under Constr.	Jan. 1, 1949	.....	Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	$26 million	Under Constr.	Aug., 1949	Hydro-Res., Inc. Texaco	McKee, Hydro-Res., Inc.	McKee
The Chicago Corp.	Carthage, Texas	Enlarge Gas Plt	210,000 mcf	$2 million	Under Constr.	June, 1949	.....	Fish Eng.	Fish Eng.
Cit-Con Corp.....	Lake Charles, La.	Lube Plant	6,000 bbls.	$35 million	Under Constr.	Oct., 1949	Texaco, Max B. Miller	Max B. Miller, Lummus	Lummus, Max B. Miller
Cities Service Oil Co.	Pampa, Texas	Gasoline Plant	18,000 mcf	.....	Contracted	1949	.....	Walco	Walco
Claiborne Gasoline Co.	Lisbon, La.	Enlarge Gasoline Plant	125,000 mcf	.....	Under Constr.	Jan., 1949	.....	Pet. Eng.	.....
Continental Oil Co.	Sonora, Texas	Gasoline Plant	10,000 mcf	$2.5 million	Contracted	July, 1949	.....	Ref. Maint.	Ref. Maint.
Continental Oil Co.	Todd (Deep) Field, Texas	Gas Recovery Plant	60,000 gals.	.....	Under Constr.	Sept., 1949	.....	Ref. Maint.	Ref. Maint.
Conden Pet. Corp.	Big Spring, Tex.	Fluid Cat. Plant	6,000 bbls.	$2 million	Under Constr.	Nov., 1949	U.O.P.	U.O.P.	Ref. Eng.
Duval Gasoline Co.	Benevidas, Tex.	Absorption Plant	10,500 mcf	$100,000	.....	Completed	.....	Republic Ref. Co.	Staff
El Paso Natural Gas Co.	Goldsmith, Tex.	Gas Treat, Plant	70,000 mcf	$903,700	Under Constr.	Jan., 1949	.....	Fluor	Staff
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	20,000 mcf	.....	Under Constr.	1st Qtr., 1949	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends	11,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	Braun	Braun
Ethyl Corp.....	Baton Rouge, La.	Mfg. Facilities	.....	$40 million	Under Constr.	Oct., 1949	.....	Stone & Webster	Stone & Webster
Gray-Wolfe Co....	Montgomery Co.	Gasoline Plant	13,000 mcf	$2 million	Under Constr.	Jan., 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.....	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Contracted	Fall, 1949	.....	Braun	Braun, W. D. Bowden
Humble O&R Co...	Katy, Texas	Add Propane, Absorption, refrigeration	Unchanged	$7 million	Under Constr.	June, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co...	Kelsey Field, Texas	Gas Injection Plant	18,000 mcf	$1,408,000	Under Constr.	May, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co...	Seeligson Field, Texas	Gas Injection Plant	20,000 mcf	$1,336,000	Under Constr.	Feb., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co...	Conroe, Texas	Add Compression—Absorption	30,000 mcf	$4,160,000	Under Constr.	Summer, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Bloomington, Texas	Gas Comp. Plant	22,000 mcf	.....	Authorized	1949	.....	.....	.....
Humble O&R Co...	Opelousas, La.	Absorption Plant	110,000 mcf	$2,800,000	Under Constr.	Summer, 1949	.....	.....	Hudson

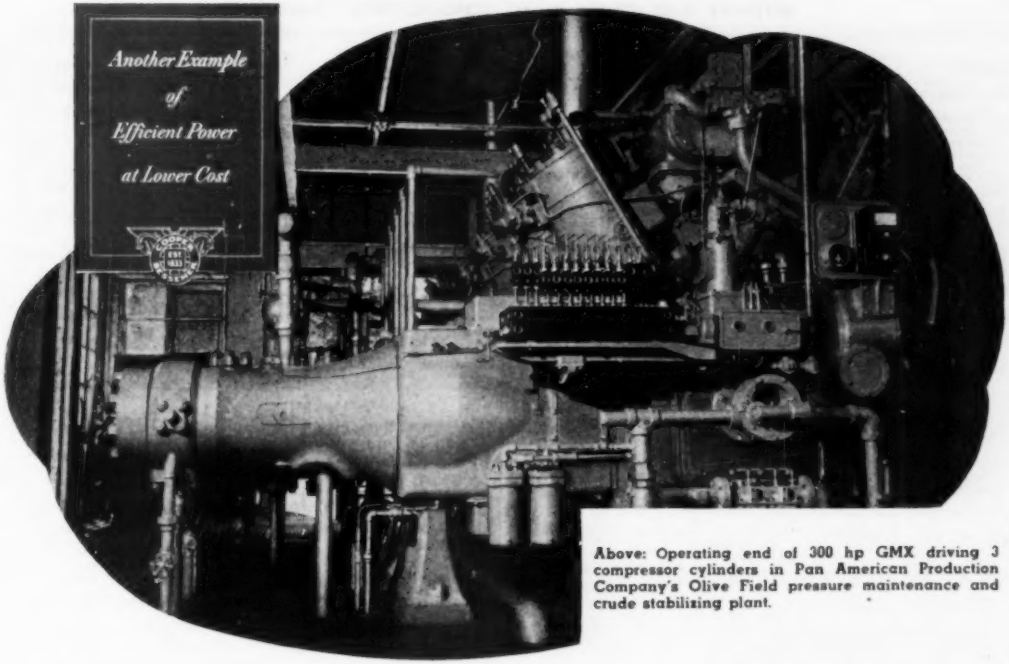
* CONTINUED ON NEXT PAGE

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Humble O&R Co.	Pickton Field, Texas	Comp.—Absorp. Plant	18,000 mcf	$2,133,000	Under Constr.	June, 1949		Fluor	Fluor
Humble O&R Co.	Baytown, Texas	Pipe Stills	45,000 bbls.	$5.8 million	Under Constr.	Late 1949		Foster-Wheeler	Foster-Wheeler
Humble O&R Co.	Baytown, Texas	Lube Extraction	7,000 bbls.	$5.3 million	Under Constr.	Late 1949		Kellogg	Kellogg
Humble O&R Co.	Flour Bluff Field, Texas	Compression Plant	12,000 mcf		Authorized	1949			
Humble O&R Co.	Jourdanton, Texas	Compression Absorption Plt.	26,000 mcf		Authorized	1949-1950			
*Jefferson Chem. Co.	Austin, Texas	Central Research Facilities			Design	1949			
La Gloria Corp.	Falfurrias, Tex.	Casinghead Gas	20,000 mcf		Under Constr.	May, 1949			
Lone Star Gas	Dallas, Texas	Hypersorption Plant	60 mcf		Design & Eng.	1949	Union Oil Co.	Hudson Foster-Wheeler	Hudson Foster-Wheeler
Magnolia Pet. Co.	Beaumont, Tex.	Lube Plant			Under Constr.	Jan. 1, 1949	Texaco	Lummus	Lummus, Kellogg
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline and Cycling	70,000 mcf Casinghead 150,000 mcf Cycled		Under Constr.	April, 1949 Partly Completed		Hudson	Hudson
Magnolia Pet. Co.	Mamou, La.	Gasoline Plant	7,000 mcf			Completed		Staff, Gaso. Plant	Gaso. Plant
McCarthy Chemical Co.	Winnie, Texas	Petro Chem		$3 million		Completed		Staff	Tellepsen
Monsanto Chemical Co.	Texas City, Texas	Rebuilding Petro-chem.		$6 million		Completed			Bellows, Leonard
Natural Gaso. Corp.	Hawkins, Tex.	Enlarge Plant	20,000 gals.		Under Constr.	Early, 1949			
Paluxy Asphalt Co.	Yazoo City, Miss.	Cracking Still	1,500 bbls.	$125,000	Under Constr.	Jan., 1949		Gaso. Plant	Gaso. Plant
Paluxy Asphalt Co.	Yazoo City, Mississippi	Gas Recovery Cat. Polymer Unit	3½ mcf	$250,000	Under Constr.	Early, 1949	U.O.P.	Koch	Self Staff
Pan American Refining Corp.	Texas City, Texas	Expand chemical Research Facilities			Contracted	Jan., 1950		Staff, H. K. Ferguson	Staff, H. K. Ferguson
*Panhandle Producing & Refg. Co.	Wichita Falls, Texas	Cat. Cracker	1,500 bbls.	$1 million	Engineering	March, 1950	U.O.P.	U.O.P., J & L Constr.	J & L Constr.
The Parade Co.	Rusk County, Texas	Add Propane Recovery	18,000 mcf	$250,000	Under Constr.	Jan., 1949		Hudson	Hudson
Petrol Refining, Inc.	Texas City, Texas	Crude Topping Units	50,000 bbls.		Under Constr.	April 1, 1949		Rust. Eng.	Rust. Eng.
Phillips Pet Co.	Alvin, Texas	Absorption Plant	120,000 mcf		Authorized	Sept., 1949			
Phillips Pet. Co.	Goldsmith, Tex.	Absorption Plant	148,000 mcf			Completed			
Phillips Pet. Co.	Etter, Texas	Petro-chem. Plant Increase	140,000 tons yr.		Authorized			Chem. Constr.	
*Phillips Pet. Co.	Goldsmith, Tex	Add to Absorption Plant	40,000 mcf		Under Constr.	April, 1949			
The Pure Oil Co.	Nederland, Tex.	MEK Dewaxing	3,500 bbls.		Under Constr.	March, 1949	Texaco	Lummus	Lummus
The Pure Oil Co.	Nederland, Tex.	Clay Contact Deasphalting, Phenol Extrac.	4,300 bbls.		Under Constr.	Feb., 1949	Juik	Kellogg	Kellogg
The Pure Oil Co.	Nederland, Tex.	MEK Dewaxing	200 bbls.		Under Constr.	Sept., 1949	Texaco	Lummus	Lummus
The Pure Oil Co.	Nederland, Tex.	Compound. Blending	1,600 bbls.		Under Constr.	Mar., 1949		Staff, Verne E. Alden	Stone-Webster
The Pure Oil Co.	Nederland, Tex.	Grease Plant	66,000 lbs.		Under Constr.	March, 1949		Staff, Verne E. Alden	Stone-Webster
Shamrock Oil & Gas Co.	Sunray, Texas	Increase Topping & Cracking Facilities	10,000 bbls.	$300,000	Under Constr.	Jan., 1949	U.O.P.	Staff	Staff
Sid Richardson Gasoline Co.	Keystone Field, Texas	Gasoline Plant	107,000 mcf		Under Constr.	Jan., 1949		J & L Constr.	J & L Constr.
Shell Chem. Corp.	Houston, Texas	Add Acetone Unit			Under Constr.	Late 1949		Braun	Braun
Shell Oil Co.	Notrees, Texas	Extension TXL Plant	30,000 mcf		Under Constr.	Early 1950		Brown & Root	Brown & Root
Skelly Oil Co.	Skellytown, Tex.	Expand Gasoline Plant			Under Constr.	Fall, 1949			J. E. Carlson
Southwestern Oil & Refg. Co.	Corpus Christi, Texas	Catalytic Reforming	5,000 bbls.	$800,000	Under Constr.	Feb., 1949		Process Eng.	Process Eng.
Stanolind O&G Co., Qtr.	Fullerton Field, Texas	Gasoline Plant	55,000 mcf		Engineering			J & L Constr.	J & L Constr.
Stanolind O&G Co., Qtr.	Slaughter, Hockley Co., Texas	Gasoline Plant	90,000 mcf		Under Constr.	April 1, 1949		Braun	Braun
Stanolind O&G Co.	Brownsville, Tex.	Chemical Plant	130,000 lbs./yr.		Under Constr.	Jan. 1, 1950		Badger	Badger
Stanolind O&G Co.	Pettus, Texas	Cycling Plant	166,000 mcf		Under Constr.	May 1, 1949		J & L Constr.	J & L Constr.
Stanolind O&G Co.	Levelland Field, Texas	Gasoline Plant			Planned	1950		Brown & Root	Brown & Root
Stanolind O&G Co.	N. Cowden, Tex.	Gasoline Plant	75,000 mcf		Engineering	1950			
Sun Oil Co.	Starr Co., Texas	Gasoline Plant	35,000 mcf	$4 million	Under Constr.	May, 1949		Stearns-Roger	Stearns-Roger
Sun Oil Co.	Jameson Field, Coke County Texas	Gasoline Plant	10,000 mcf	Part of $12 million	Under Constr.	March, 1949	Pet. Eng.	Pet. Eng. Pritchard	Pet. Eng. Pritchard
The Texas Co.	Port Arthur, Texas	Lube & Wax Additions	137,500 Crude 12,500 bbls. Oil		Under Constr.	April 1, 1949		Foster-Wheeler	Foster-Wheeler
The Texas Co.	Electra, Texas	Gasoline Plant	2,000 mcf		Under Constr.	Jan., 1949		Texaco	
The Texas Co.	Lafitte, La.	Expand Gasoline Plant	6,500 mcf					Hudson	Hudson
The Texas Co.	Port Arthur, Texas	Change to Linde, Solutizer Treating Facilities			Under Constr.	March 1, 1949		Foster-Wheeler	Foster-Wheeler
Texoma Natural Gas Co.	Stinnett, Texas	Additional Compression	150,000 mcf	$2.5 million		Completed			Midwestern Construction Co.
United Gas Co.	Carthage, Texas	2nd Gas Plant	100,000 mcf	$3.5 million	Under Constr.	July, 1949		Hudson	Hudson
U. S. Ind. Chemicals Co.	Brownsville, Texas	Petrochemical Plant			Contracted	1949		Badger	Badger
Waggoner Est. Ref.	Electra, Texas	Crack Unit Revisions		$250,000	Under Constr.	Jan., 1949	U.O.P.	Ref. Eng.	Ref. Eng.
Warren Pet. Corp.	Breckenridge, Texas	LPG Extraction	1,500 bbls.			Completed		Staff	Staff
Warren Pet. Corp.	Hawkins, Texas	Add Plant	20,000 mcf		Under Constr.	March, 1949		Gaso. Plant	Gaso. Plant.
Warren Pet. Corp.	Holliday, Texas	Expansion & Propane Prod.	2,500 bbls.			Completed		Staff	Staff
Warren Pet. Corp.	Taylor's Corner, Texas	Gasoline Plant	5,000 mcf		Under Constr.	March, 1949		Walco	Walco
Warren Pet. Corp.	Wichita Falls, Tex. (Madden Plant)	Gasoline Plant	35,000 gals.		Under Constr.	March 1, 1949		Walco	Walco
Warren Pet. Corp.	Gladewater, Tex.	Propane Unit	30,000 gals.		Under Constr.	Feb. 1, 1949		J. B. Gill Co.	J. B. Gill Co.
ROCKY MOUNTAIN									
The Carter Oil Co.	Billings, Mont.	Crude Cat. Crk.	30,000 bbls.	$20 million	Under Constr.	3rd Qtr., 1949		U.O.P., S.O.D., Fluor	Fluor
Continental Oil Co.	Billings, Mont.	Complete Ref. Cat. Crack	7,500 bbls.	$8.5 million	Under Constr.	Oct., 1949	U.O.P.	U.O.P., J & L Constr.	J & L Constr.

• CONTINUED ON PAGE 146

Another Example of Efficient Power at Lower Cost



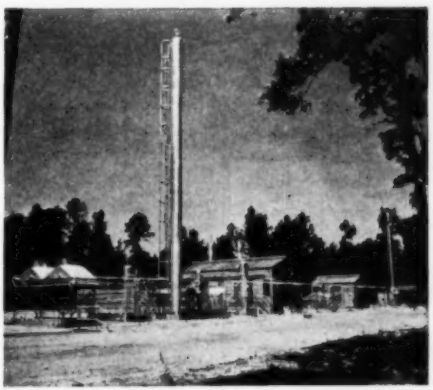
Above: Operating end of 300 hp GMX driving 3 compressor cylinders in Pan American Production Company's Olive Field pressure maintenance and crude stabilizing plant.

"BIG-TIME" compressor performance for small field gas conservation

OLIVE FIELD, TEXAS, rates as one of the smallest fields to utilize pressure maintenance. Here, in Pan American Production Company's pressure maintenance and crude stabilizing plant, two of the smallest Cooper-Bessemer V-angles, Gmx's, meet the compressing needs ideally.

The two units, 200 and 300 bhp, have a combined capacity of 4,166,000 cu. ft. a day. The gas, formerly wasted, is compressed through 3 stages from 250 psi to 4,800 psi injection pressure, all residue gas being returned to the producing formation through a single injection well.

If your plans call for compressor service anywhere from 200 to 2,400 bhp per unit, there are modern, highly efficient Cooper-Bessemer V-angles, GMX's, GMV's, or GMW's, that offer you big savings in the cost of installation, maintenance and over-all, long-range operation.



General view of plant. All gas, formerly wasted, is now returned to producing reservoir or used as plant fuel.

The **Cooper-Bessemer** *Corporation*

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York City Washington, D. C. Bradford, Pa. Parkersburg, W. Va. San Francisco, Calif. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash. Tulsa, Okla. Shreveport, La. St. Louis, Mo. Los Angeles, Calif. Caracas, Venezuela Gloucester, Mass. Colmes Engineering Co., New Orleans, La.

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Empire State Oil Co.	Thermopolis, Wyoming	Crude, Vacuum Units	5,000 bbls.	$325,000	Engineering Underway	May, 1949	.....	Ref. Eng.	Ref. Eng.
Gulf Oil Corp.	Eunice, N. M.	Gasoline Plant	80,000 mcf	.....	Under Constr.	Middle 1949	.....	Hudson	Hudson
New Mexico Asphalt Refg. Co.	Artesia, N. M.	Crude Unit	7,500 bbls.	$350,000	Material being Received	May, 1949	.....	Geo. Armistead	Staff
Phillips Pet. Co.	Oil Center, N.M.	Absorption Plant	†48,000 mcf	.....	.....	Completed	.....	.....	.....
The Pure Oil Co.	Worland, Wyo.	Gasoline Plant	.....	.....	Projected	.....	.....	.....	.....
Salt Lake Refg. Co.	Salt Lake City	Crude Dist. Unit	25,000 bbls.	$5 million	.....	Completed	.....	.....	Bechtel
Skelly Oil Co.	Lea County, N. M.	Expanding Gasoline Plant	60,000 gals.	.....	Under Constr.	Mid 1949	.....	.....	J. E. Carlson
Socony-Vacuum	Casper, Wyo.	T C C	6,000 bbls.	.....	Under Constr.	March, 1949	.....	Staff	Cat. Constr.
Southern Union Gas Co.	Bloomfield, N. M.	Gasoline Plant	20,000 mcf	$1 million	Contracted	June, 1949	.....	Ref. Maint.	Ref. Maint.
Standard Oil (Ind.)	Casper, Wyo.	Cat. Crack	8,000 bbls.	.....	Under Constr.	Early 1949	.....	.....	Kellogg
Stanolind O&G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf	.....	Under Constr.	April, 1949	.....	Stone & Webster	Stone & Webster
Texas Gulf Sulphur Co.	Worland, Wyo.	Sulfur Recovery Plant	30,000 mcf	.....	Projected	.....	.....	.....	.....
U. S. Bureau of Mines	Rifle, Colo.	Shale Oil Refy.	300 bbls.	$750,000	Under Constr.	Early 1949	.....	Ref. Eng.	Ref. Eng.
Utah Oil Refg. Co.	Salt Lake City, Utah	Propane Deasphalting	10,500 bbls.	$2.5 million	Under Constr.	Early 1949	.....	Kellogg	Kellogg
Warren Pet. Corp.	Monument, N. M.	Gasoline Plant Enlargement	2,500 bbls.	.....	.....	Completed	.....	Warren	Dresser Eng.
Western States Refining Co.	North Salt Lake City, Utah	New Refinery	2,500 bbls.	$350,000	Under Constr.	Jan., 1949	.....	.....	.....
WEST COAST									
California Asphalt Corp.	Portland, Ore.	Asphalt Packing Plant, Warehouse	.....	.....	Under Constr.	March, 1949	.....	Staff	.....
General Petroleum Corp.	Torrance, Calif.	TCC Furnace Expansion	4,000 bbls.	.....	Under Constr.	Early 1949	.....	Staff-Lummus	Lummus
Hancock Chem. Co.	Watson, Calif.	Elemental Sulfur Plant	50 tons	.....	.....	Completed	.....	Badger	Badger
*Hercules Powder Co.	Hercules, Calif.	Ammonia Plant	.....	.....	Under Constr.	Summer 1949	.....	Staff	Bechtel
Mohawk Pet. Co.	Bakersfield, Calif.	Topping and Feed Preparation Unit	7,500 bbls.	$220,000	Under Constr.	Feb., 1949	None	Earle W. Gard	Key Constr.
Robt. S. Lytle, Ope	Coalinga, Calif.	H_2S Removal	33,000 mcf	$175,000	Projected	1 year	Fluor	Fluor	Fluor
Shell Chem. Corp.	Pittsburg, Calif.	Add Ammonia Plant	225% of prewar	.....	.....	Completed	.....	Bechtel Corp.	Bechtel Corp.
Shell Chem. Corp.	Pittsburg, Calif.	Add Ammonium Sulfate Plant	180% of prewar	.....	.....	Completed	.....	Bechtel Corp.	Bechtel Corp.
Shell Chem. Corp.	Dominguez, Cal.	Add Acetone	.....	.....	Under Constr.	Feb., 1949	.....	Braun	Braun
Shell Oil Co.	Ventura, Calif.	Gasoline Plant	.....	.....	Under Constr.	.....	.....	Staff	Ref. Maint.
Shell Oil Co.	Wilmington, Cal.	Extend Cracking Plant Compressors	.....	.....	Under Constr.	Middle 1949	.....	Fluor	Fluor
Shell Oil Co.	Wilmington, Cal.	Extend Tank Storage	.....	.....	Under Constr.	Middle 1949	.....	Staff	Chicago Bridge & Iron Co.
Shell Oil Co.	Martinez, Calif.	Lube Handling Facilities	.....	.....	Under Constr.	Dec., 1949	.....	Staff	Staff
Standard Oil Co. of Calif.	Bakersfield, Calif.	Crude Dist.	10,000 bbls.	$7.5 million	Under Constr.	Mid 1949	Braun	Braun	Braun
Standard Oil Co. of Calif.	Bakersfield, Calif.	Thermal, Crk., Gaso. Stabil.	9,000 bbls.	.....	Under Constr.	.....	U.O.P.	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Gaso. Treating Filling Plant Modernization	.....	$2 million	Under Constr.	March, 1949	.....	.....	.....
Standard Oil Co. of Calif.	Richmond, Cal.	Grease, Wax Plant, Dock Facilities	82,000 lbs.	$13 million	.....	Completed	U.O.P., Texaco (Wax)	W. G. Pough	Barrett & Hilp, Swinerton & Walberg & Ben C. Gerwick, Inc. Humiston-Roendahl, Inc.
Standard Oil Co. of Calif.	El Segundo, Cal.	Cracked Naphtha Rerun Still	22,000 bbls.	$2.6 million	Contract let	Aug., 1949	.....	Braun	Braun
Standard Oil Co. of California	Richmond, Calif.	TCC Clay Repurification	50 tons	$250,000	.....	Completed	Max B. Miller	Max B. Miller	Humiston-Roendahl, Inc.
*Union Oil Co. of California	Oleum, Calif.	Asphalt Refined Oil Loading Facilities	.....	$457,000	Contracted	1949	.....	Early Constr.	Early Constr.
Union Oil Co. of California	Oleum, Calif.	Revision of Refining Facilities	.....	$4.2 million	Engineering	1949	.....	Parsons	Ref. Maint.
Union Oil Co. of California	Oleum, Calif.	Revise Lube, Dewax Units	1,900 bbls.	$1.7 million	Contracted	1949	Union Oil Co.	Kellogg	Kellogg
Union Oil Co. of California	Oleum, Calif.	Improvements to Compound & Grease Facilities	.....	$1.2 million	Engineering	1949	.....	J. M. Montgomery & Co.	.....
Union Oil Co. of California	Oleum, Calif.	Duo-Sol Unit	6,000 bbls.	$2.9 million	Contracted	1949	Max Miller	Max Miller	Max Miller
Union Oil Co. of California	Oleum, Calif.	Tankage and Utilities	.....	$2 million	Contracted	1949	.....	Ehrhart & Arthur	Ref. Maint.
Union Oil Co. of California	Wilmington, Calif.	H_2S Recovery	30,000 bbls.	$200,000	Engineering	1949	No	Ehrhart & Arthur, Inc.	.....
FOREIGN									
Agwi Pet. Corp.	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
Anglo-Iranian Oil.	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian Oil.	Abadan, Iran	Cat. Craker	30,000 bbls.	.....	Under Constr.	.....	.....	Foster-Wheeler	Foster-Wheeler
Anglo-Iranian Oil.	Abadan, Iran	Lube Plant	400 bbls.	.....	Under Constr.	.....	Texaco	Badger	Badger
Anglo-Iranian Oil.	Isle of Grain, Thames and Medway Estuary, Eng.	Central Refining Unit	80,000 bbls.	$120 million	Planning	1952	Texaco (Lube Unit)	.....	.....
Anglo-Transvaal Consolidated Investment Co.	Vall River Union, South Africa	Synthetic Gasoline and Diesel Oil Plant	.....	$50-60 million	Planned	.....	.....	.....	.....
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4,800,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Steam Power Plant, etc.	20,000 kw	$9,400,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Add Power Generating Unit	10,000 kw	$1,750,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
*Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Refinery Additions	.....	.....	Under Constr.	1949	.....	Bechtel	Bechtel
Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.	.....	Projected	.....	.....	.....	.....

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Bahrein Pet. Co, Ltd.	Bahrein Island	Expansion Program	.....	$8.3 million	Under Constr.	Oct., 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
*Bahrein Pet. Co., Ltd.	Bahrein Island	Crude Still, Utilities	55,000 bbls.	$9.1 million	Planned	June, 1950	.....	Lummus, Bechtel	.....
Bataafsche Petroleum Maatschappij	Rotterdam-Pernis, Holland	Dewaxing Unit	60,000 bbls.	.....	.....	.....	Texaco (Dewax)	.....	.....
British-American Oil Co., Ltd.	Montreal East P. Q., Canada	Cat Cracking and Cat Poly	13,300 bbls.	.....	Under Constr.	Late 1949	Kellogg-U.O.P.	Kellogg	Kellogg
British Pet. Chem. Ltd.	Grangemouth, Scotland	Petro-Chem	.....	$20 million	Planned	.....	.....	S. & W. Badger	S. & W. Badger
Burmah Oil Co.....	Burma	Furfural Plant	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co.....	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
California-Texas Co., Ltd.	Cartagena, Spain	Refinery	15,000-20,000 bbls.	.....	Proposed	March, 1951	.....	.....	.....
Caltex Pet. Maatschappij, N. V.	Rotterdam, Holland	Complete	20,000 bbls.	$18 million	Under Constr.	Early 1950	.....	McKee, Badger, U.O.P.	McKee
Caltex Maatschap..	Rotterdam	SO_2 Plant	1,800 bbls.	$600,000	Designing	.....	.....	Badger	.....
Cie. de Raffinage Shell-Berre	Berre, France	Capacity Increase	47,000 bbls.	.....	Planned	.....	.....	.....	.....
Cie. Française de Raffinage	Gonfreville, France	Lube Unit	2,500 bbls.	.....	Projected	.....	.....	.....	.....
Cie. Française de Raffinage	Gonfreville, France	Capacity Increase	20,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Cie. Française de Raffinage	Provence, France	Distillation Unit	20,000 bbls.	.....	.....	1950	.....	.....	.....
Cie Française de Raffinage	Provence, France	Lube Oil Unit	2,500 bbls.	.....	.....	1950	.....	.....	.....
Cie. Industrielle des Petroles	Frontignan, France	Capacity Increase	12,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
Cie. de Raffinage Shell-Berre	Petit Couronne, France	Lube Unit	.....	.....	Planned	.....	.....	.....	.....
Compania Española de Petróleos S.A. (C.E.P.S.A.)	Canary Islands, Spain	Lube, Wax Facilities	5,000 bbls.	$4½ million	Under Constr.	Early 1950	Texaco, Standard, N. J.	Foster Wheeler	Foster-Wheeler
*Conselho National de Petroleo	Santos, Brazil	Complete Refinery	20,000 bbls.	$30 million	Projected	.....	.....	.....	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	By 1950	.....	Badger	Badger
Consolidated Ref. Ltd.	Haifa	General Facilities	.....	.....	Under Design	.....	.....	Badger, Ltd.	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Designing	.....	Texaco	Badger, Kellogg	Lummus, Kellogg
Creole Pet. Corp...	Amuay Bay, Venezuela	Cat. Cracking	60,000 bbls.	$70 million	Under Constr.	1950	.....	.....	.....
Creole Pet. Corp...	Mulata Field, Venezuela	Stabilization and Repressuring Plants	.....	.....	.....	.....	.....	.....	.....
Creole Pet. Corp...	El Roble Field, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
Egyptian Government	Cairo, Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
Husky Refg. Co....	Lloydminster, Canada	Increase Refinery Capacity	7,500 bbls.	$500,000	.....	Completed	Petreco	Staff	Staff
Imperial Oil, Ltd..	Edmonton, Canada	Thermal, Crack Crude Dist.	6,000 bbls.	$8.7 million	Under Constr.	Jan., 1949	.....	Barnes, Imp. Oil	Barnes
Imperial Oil, Ltd..	Edmonton, Canada	Increase Capacity	11,000 bbls.	$2½ million	Planned	Dec., 1949	.....	Staff, Barnes	Barnes
Imperial Oil, Ltd..	Leduc Field, Canada	Gas Absorption	.....	$1.5 million	Projected	.....	.....	.....	.....
Industrie Chimiche Italiane Petroli	Mantua, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
Kuwait Oil Co.....	Kuwait	Topping Unit	20,000 bbls.	$2 million	Under Constr.	.....	.....	Badger	Badger
Mediterranean Ref. Co.	Trans-Arabian P.L. Mediterranean Term.	Refinery	.....	.....	"Paper stage"	.....	.....	.....	.....
Mene Grande Oil Co.	West Guara, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
National Oil Refineries, Ltd.	Llandarcy, Wales	Crude and Reform.	40,000 bbls.	$10 million	Designing	.....	.....	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Lubes & Wax	1,200 bbls.			.....	Texaco	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.	.....	Contracted	.....	.....	H. W. P.	.....
Pechelbronn S. A. E. M.	Merkwiller, France	Capacity Increase	1,550 bbls.	.....	Authorized	1950	.....	.....	.....
Petro Carbon, Ltd..	Partington, England	Cat. Cracker Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd...	Partington, England	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
Petróleos Mexicano	Ciudad Madero, Mexico	Crude Unit	25,000 bbls.	$2 million	Under Constr.	Jan., 1949	None	Staff	Staff
Petróleos Mexicano	Poza Rica, Mex.	Gas Purification, Pressure Maintenance, etc.	.....	$13 million	Contracted	Early 1950	.....	McKee	McKee
Petróleos Mexicanos	Salamanca, Mex.	Crude, Gasoil, Cracking	30,000 bbls.	$12 million	Contract let	1949	U.O.P.	McKee	McKee
Philblack, Ltd.....	Avonmouth, England	Carbon Black Plant	50 million lbs. Yearly	$5 million	Contracted	1950	Phillips	H. W. P.	H. W. P.
Porto Marghera Rfg.	Venice, Italy	Enlarging	.....	.....	Contracted	.....	.....	H. W. P.	H. W. P.
Raffineries de Pétrole de la Gironde	Ambes, France	Refinery	13,000 bbls.	$7.8 million	Under Constr.	Early 1950	.....	U.O.P., McKee	McKee
Raffineries Françaises de Pétrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.	.....	.....	.....	.....	.....	.....
Raffineries di Napoli, S. p. A.	Naples, Italy	Topping Unit	10,000 bbls.	.....	Under Constr.	Early 1949	.....	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Contact Plant	.....	.....	Under Constr.	Mid 1949	.....	Staff	Staff
*Olii Mineral: *Raffineries di Napoli, S. p. A.	Naples, Italy	Furfural Unit	1,000 bbls.	.....	Under Constr.	Early 1950	Texaco	Staff	Staff
*Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	MEK Unit	1,000 bbls.	.....	Design	Early 1950	Texaco	Lummus	Staff
*Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Deasphalting Unit	1,100 bbls.	.....	Design	Mid 1950	Tuik	Lummus	Staff

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
*Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Furfural Unit	1,000 bbls.	.....	Under Constr.	Early 1949	Texaco	Staff	Staff
*Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Grease and Compounding Plant	.....	.....	Under Constr.	Early 1950	.....	Staff	Staff
Régie Autònome des Petroles	Boussens, France	Absorption Plant	42,000 mcf	$2 million	Under Constr.	Early 1949	.....	Hudson	Etablissements
Scottish Oil, Ltd.	Grangemouth, Scotland	Crude	28,000 bbls.	$28 million	Planned	.....	.....	.....	Schneider
Scottish Oils, Ltd.	Grangemouth, Scotland	Cat. Crk.	5,000 bbls.		Planned	.....	.....	.....	.....
Shell Chem. Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chem. Corp.	Shell Haven, Enrland	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chem. Corp.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Oil Co. of British Columbia	Shellburn Ref., Vancouver	Add Crude Distillation	7,500 bbls.	$600,000	Under Constr.	Feb., 1949	.....	Staff	Staff
Shell Oil Co. (Venezuela)	Puerto Cardon, Venezuela	Complete Refg.	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Shell Oil Co.	Heysham, Eng.	Remodel & Redesign Crude Plant	30,000 bbls.	.....	Under Constr.	Mid 1949	.....	.....	.....
Société Generale des Huiles de Pétrole	L'Avera, France	LPG and Gas Stabilizing Units	.....	.....	Under Constr.	.....	.....	.....	.....
Société Generale des Huiles de Pétrole	Dunkirk, France	Crude Reform.	33,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Société Generale des Huiles de Pétrole	Courchelettes, France	Lube & Wax	6,700 bbls.	.....	Under Constr.	1950	Texaco	.....	.....
*Societa per Azioni Raffinerie Padane	San Matrino di Trecate, Italy	Refinery	13,000 bbls.	.....	Proposed	.....	.....	.....	.....
Standard Francaises des Pétroles	Port Jerome, France	Capacity Increase	30,000 bbls.	.....	Authorized	.....	.....	.....	.....
Standard Francaises des Pétroles	Port Jerome, France	Dewaxing Plant	1,000 bbls.	.....	Planned	.....	.....	.....	.....
Standard Francaises des Pétroles	Port Jerome, France	Deasphalting Plant	2,000 bbls.	.....	Planned	.....	.....	.....	.....
Stora Kopparberg	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
Venezuelan Pet. Co. (Sinclair)	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.	.....	Clearing site	.....	.....	.....	.....
Yacimientos Petroliferos Fiscales	La Plata Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.	Early 1949	.....	Houdry Process Cat. Constr.	Cat. Constr.
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Boliva	Crude Plant	3,000 bbls.	.....	.....	1950	.....	Foster-Wheeler	Foster-Wheeler
YPF Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1949	.....	Foster-Wheeler	Foster-Wheeler

* First appearance in tabulation. † Added capacity.

NOTE—Ampeco—Ampeco Engineering Co. Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Bros., McCone Co. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat. Constr.—Catalytic Construction Co. Chem. Constr.—Chemical Construction Co. Clark's—Clark's Construction and Engineering Co. Dresser—Dresser Engineering Corp. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. H. W. P.—Head Wrightson Processes, Ltd. Hydro Ren.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J & L Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch Eng.—Koch Engineering Co. Koppers—Koppers Co., Inc. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. McKee—Arthur G. McKee Co. Mid-Continent—Mid-Continent Engineering Co. Max Miller—Max B. Miller & Co. Parsons—The Ralph M. Parsons Co. Pet. Eng.—Petroleum Engineering, Inc. Petro—Petroleum Rectifying Co. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Inc. S. O. D.—Standard Oil Development Co. Stearns-Roger—Stearns-Roger manufacturing Co. Tellepsen—Tellepsen Construction Co. Texaco—Texaco Development Co. U. O. P.—Universal Oil Products Co. Walco—Walco Engineering. Wohfeld—Wohfeld Construction Co. Equally owned by California Texas Corp. and Socony-Vacuum Oil Co., Inc.

Scottish Oils Planning $30 Million Expansion Unit

Scottish Oils, Ltd., has planned an expansion of its existing refinery at Grangemouth, Scotland, estimated to cost $30 million. Last month the company also approved plans for a $20 million chemicals plant to adjoin the refinery. Completion of the dual project will make Grangemouth one of the important petroleum centers in Great Britain.

Catalytic cracking units will be charged with Middle East crude oil. Annual production will be doubled with the enlarged facilities producing approximately 1,742,500 barrels of gasoline and about 2,464,200 barrels of heavy fuel oil.

Panhandle Company Plans Catalytic Cracking Unit

Panhandle Producing and Refining Company will install a catalytic cracking unit at its Wichita Falls, Texas, plant. The $1 million unit, the first in North Texas, will increase the refinery's crude-oil capacity from 4000 to 6000 barrels daily. Present cracking capacity is 1500 barrels daily. Operation of the unit will be run by electronic controls from a central board.

Engineering details of the unit will be completed by March, 1949. Actual construction will start at that time, taking about a year to complete. The approximate completion date is March, 1950. Engineering work will be done by Universal Oil Products Company and Jones & Laughlin Supply Company.

Gulf Completes $19 Million Expansion at Port Arthur

Gulf Oil Corporation completed its $19 million expansion program at Port Arthur, Texas early last month. The new equipment will add 66,000 barrels to the daily crude charging capacity of the refinery.

Construction included a desulphurization unit, a polyform unit, three atmospheric-vacuum topping stills and an extension of docking facilities. At present the desulphurization and polyform units will be operated jointly to produce a higher quality of gasoline from straight-run gasoline, naphtha fractions and light hydrocarbons.

With these new processing units Gulf will be able to convert a greater portion of the incoming crude oil either to fuel or to gasoline, depending upon the demand.

Continental's Billings Plant Nears Half-way Mark

Construction of Continental Oil Company's $9.5 million refinery at Billings, Mont., has passed the half-way mark and completion is foreseen in October or November of 1949. It will have a daily crude oil capacity of 7500 barrels and will manufacture a high octane gasoline, burning fuels and residual oils.

Completed or near completed are the tank car loading rack, truck loading rack, shop and warehouse, office building, cooling tower, oil trap, roadways, two crude tanks with capacity of 120,000 barrels each, railway sidings, marketing warehouse and ethyl plant.

A skeletonized portion of the catalytic structure has been set up and work is continuing on the unit. Work is also continuing on the other sections of the plant.

Purchasing Agent Named

H. C. Hager has been named purchasing agent for National Co-operative Refinery Association, McPherson, Kan. He recently resigned from the purchasing department of Sinclair-Prairie Oil Company, Tulsa.

There's an old saw among manufacturers that "you can't please them all," but if this is the rule, Taylor Forge is the exception that proves it!

As for most good things, there's a good reason: Taylor Forge brought and applied to the pipe-welding field a mature forging experience that was *full-grown* long before welding fittings were produced on a commercial scale. And it was this informed experience, alloyed with resourceful forging skill, that Taylor Forge merged in the design of welding fittings which, literally, "have everything."

Hence, you find features that appeal to the engineering judgment of the designer and materials engineer, such as engineered strength distribution and close-control metallurgy, as you would expect from fittings made *by* engineers *for* engineers. But you also find features that appeal to their economic sense . . . the common sense of convenience and utility.

These are the low-cost features that justify the preference of the construction superintendent, the maintenance man, and the welding foreman: Tangents that make lining up easier; quarter markings that guide the work; clean lathe-bevels that mean better, faster welding; clear identifications; uniform and geometric dimensional accuracy; widest range of types and sizes.

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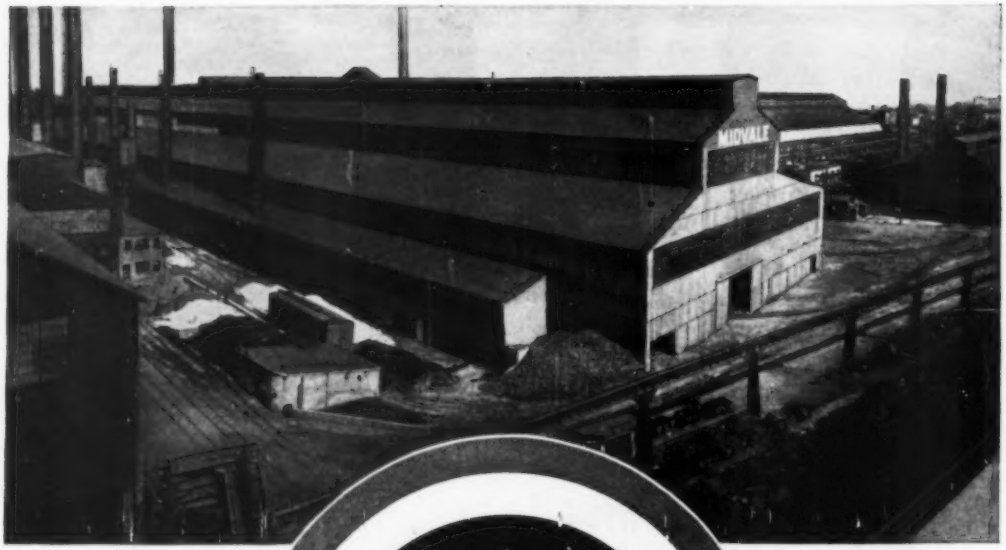

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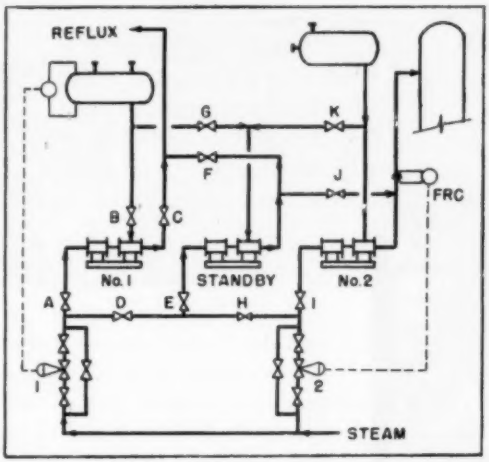
Maintenance and Operation Hints

HOW TO DO IT

HOW—Standby Pump Is Controlled

USE of a single pump as standby for two other pumps in continuous service pumping liquids has become an accepted practice among design engineers.

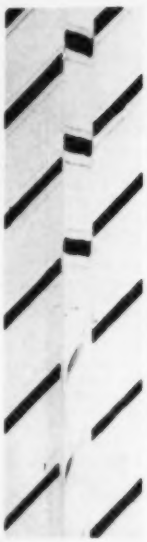
In some cases, although the pumps in service are controlled by instruments, the operators prefer that the standby pump be controlled manually during the emergency period. Where instrument control is considered desirable, or necessary, various systems have been used. For example, the system illustrated in the diagram is typical of standby pump control in use in many plants. Pump No. 1 supplies reflux to a depropanizer, and pump No. 2 pumps reflux to a debutanizer. The standby pump was designed as standby for the depropanizer reflux pump since this is the lightest of the two materials being handled. All three are the same size, steam-driven reciprocating pumps.



The steam supply of both pumps in continuous service is instrument controlled. No. 1 by a liquid level instrument on the reflux accumulator tank, and No. 2 by a flow meter in the pump discharge line. Pump No. 1 supplies about 75 gallons per minute and No. 2 about 50 gallons per minute. As shown in the diagram, the intake and discharge lines are manifolded to permit the standby pump to be used in place of No. 1 or No. 2. By manifolding the steam supply line to the pumps and placing the steam control valves in two separate lines to the manifold, the control valve for the pump in service can be used for the standby pump without changing the controlling instrument setting.

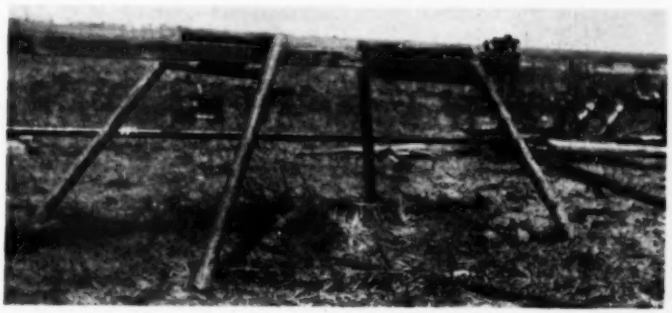
HOW TO MAKE—Gauge Level More Visible

IN VESSELS containing colorless liquids, such as steam boilers or light hydrocarbon processing equipment, operators frequently experience annoyance with conventional tubular gauge glasses through an inability to distinguish easily the indicated liquid level. There frequently is little contrast in the appearance of the liquid and vapor portions of the gauge glasses. The scheme shown here can be used to overcome this difficulty. Dark diagonal stripes are painted or otherwise placed on a light background which is located immediately behind the gauge glass. The appearance of segments of these dark stripes seen through the gauge glass affords a high contrast, both in the apparent width of the stripes and in the extent of their rotation, between the liquid filled and the vapor filled portions of the glass.



HOW TO—Make Handy Collapsible Work Bench

WHERE it is necessary to perform maintenance work in various parts of the yard or field, a collapsible work bench such as shown in the accompanying photo will come in handy. Made from 2-inch pipe and one or more lengths of 2-inch plank, the bench can be assembled for use in a few seconds without the use of bolts or wrenches. Exactly three inches separate the horizontal pipe members. One plank is fitted with a pipe vise.



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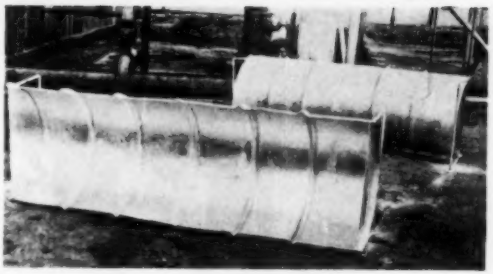
HOW TO MAKE—

Pans for Catching Lathe Cuttings

LIGHTWEIGHT, effective and easily moved pans for catching cuttings, shavings and other waste falling from the bed of a lathe can be cheaply made from standard non-return oil drums. For good appearance, the drums should not be too badly battered nor should they have large holes, unless patched. After thorough cleaning with steam or soap to remove all hydrocarbons, one head is cleanly cut from the drum, after which the cylindrical body is cut into equal halves. The smoothly cut open ends are joined by welding to produce a trough twice the length of the original drum. A heavy support of round iron is welded to each end of the trough to prevent tipping and to keep the pan upright in position beneath the bed of the lathe. For better appearance, both inside and outside are sand blasted and sprayed with aluminum paint. These pans are more easily handled than are the wooden boxes frequently used for the same purpose, and they have further advantages in that they retain but do not absorb cutting oil, thereby keeping oil from the shop floor and reducing the fire hazard.



Oil drums cut in half and welded together lengthwise make inexpensive and sturdy pans for lathe cuttings. The pans are finished by sand-blasting and spraying with aluminum paint.

HOW TO—

Replace Electric Motor Bearings In Gasoline Plant

THE difficulties encountered in replacing the roller bearings in the large electric motors in a gasoline plant were eliminated by the maintenance crew, who use a high flash point oil in heating the bearings to about 350° F.

The bearing is placed in a container and covered to a depth of about six inches by the oil, which serves as a medium to supply even heat to the bearing and cause it to expand. When the bearing reaches the required temperature, it is removed from the oil and slipped over the shaft of the motor to the correct position before it cools.

In one case, the method has been used successfully where the bearings are 0.001 of an inch undersize, so that the inner race of the bearing will not turn. These bearings were very difficult to drive or press onto the shaft of the motor. The old bearing is removed, either by cutting or by use of a bearing puller.

HOW TO—

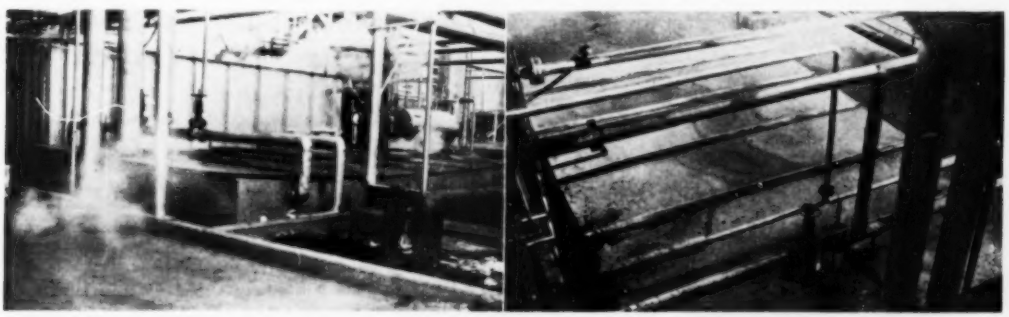
Produce Steam by Waste Heat Recovery

FIVE thousand pounds of steam per hour is being produced by Leonard Refineries, Inc., in Alma, Mich., with the only cost the initial investment for heat transfer equipment and the usual maintenance expense. Thus this steam is more or less a 'lagniappe,' a 'pilon' or in plain United States, "for free." Similar savings in many cases, can be made in other refineries where hot bottoms must be cooled from a high to a low temperature.

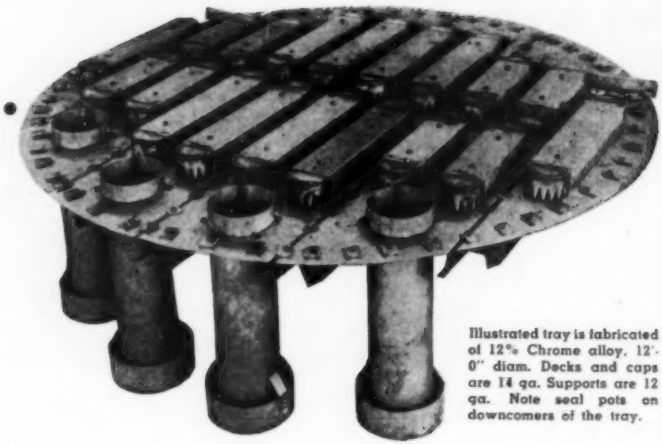
At Leonard, a small catalytic cracking unit processes a wide variety of feed stocks. Such stocks are distilled by flashing with two 14 million Btu.-per-hour feed preparation heaters into a virgin reactor gasoil charge, and about 30 percent tar bottoms. These bottoms are withdrawn from the flash vessel at approximately 750° F. This temperature must be reduced so the asphalt can be handled safely in subsequent operations. This cracking unit has another self-contained steam generator which converts heat from coke burning for the catalyst regeneration into steam. The tar bottoms steam generator is tied into this other steam generator and system. The operating pressure for the generators is 290 psig.

Eighteen hundred barrels of tar separator bottoms are produced each 24 hours, and are passed through a battery of 24 heat exchanger sections which are installed at approximate ground level. Water from the cracking unit steam generator feed tank flows downward to these tar bottoms exchangers through a line leading from the bottom of the feed tank in the cracking unit supporting structure and steam and water mixture returns from the opposite end of the exchangers back to the feed drum, which also serves as a water-steam separator.

The 24 exchanger sections are installed in two batteries and piped so that all operate in parallel. The two batteries, when in usual operation are as one unit. They are arranged into batteries so that half of the exchangers can be taken out of service without disrupting the operation of the entire installation. Water flows by gravity through the tubes of the exchangers while the tar bottoms pass hrough the shells and around the tubes. In generating 5000 pounds per hour of steam, the bottoms are reduced in temperature from 750° F. to 450° F., so that the load on the regular bottoms coolers and on the plant cooling water system is reduced a worthwhile amount.



From the ground level, the steam generating plant in Leonard's refinery at Alma, Mich., is shown at left with steel covering and part of the piping. Looking down upon the steel clad insulated top at right of a bank of 24 exchangers employed by Leonard to generate 5000 pounds of steam per hour with waste heat.



Illustrated tray is fabricated of 12% Chrome alloy. 12'-0" diam. Decks and caps are 14 ga. Supports are 12 ga. Note seal pots on downcomers of the tray.

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Corrosion allowance is not a factor when your trays are made of alloys. GLITSCH "Truss-Type" bubble trays and bubble caps have been fabricated from 18-8 stainless steel, 12% chrome, 17% chrome, Monel, Hastelloy, Everdur, copper and brass.

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Texas Casinghead Gas Conservation Growth Since September, 1945

(Data as of End of 1948)

DISTRICT	COMPLETED			UNDER CONSTRUCTION			CONSTRUCTION AUTHORIZED			TOTAL		
	No. of Projects	Daily Volume Casinghead Gas Used (Mil. Cu. Ft.)	Approximate Cost for Casinghead Facilities	No. of Projects	Daily Volume Casinghead Gas Used (Mil. Cu. Ft.)	Approximate Cost for Casinghead Facilities	No. of Projects	Daily Volume Casinghead Gas Used (Mil. Cu. Ft.)	Approximate Cost for Casinghead Facilities	No. of Projects	Daily Volume Casinghead Gas Used (Mil. Cu. Ft.)	Approximate Cost for Casinghead Facilities
Dist. 1—South Central	...	...	...	...	...	...	1	17.5	6,080,000	1	17.5	6,080,000
Dist. 2—Middle Gulf	5	63.0	6,055,000	6	52.5	3,594,000	1	20.0	2,500,000	12	135.5	12,242,000
Dist. 3—Upper Gulf	16	240.9	25,773,000	5	67.0	9,800,000	1	18.0	1,215,000	22	325.9	36,788,000
Dist. 4—Lower Gulf-S.W.	19	198.5	12,565,000	11	136.8	15,385,000	1	50.0	2,500,000	31	385.3	30,450,000
Dist. 5—East Central	...	...	...	1	7.0	3,028,000	1	5.0	2,500,000	2	12.0	5,528,000
Dist. 6—Northeast	10	43.5	853,000	1	19.0	898,000	...	....	.....	11	62.5	1,751,000
Dist. 7-B—North Central	5	31.5	2,591,000	1	4.0	1,000,000	...	....	.....	6	35.5	3,591,000
Dist. 7-C—West Central	1	25.0	4,000,000	4	136.0	12,100,000	...	....	.....	5	161.0	16,100,000
Dist. 8—West Texas	16	311.6	30,597,000	11	517.5	90,700,000	6	143.0	14,000,000	33	972.1	135,297,000
Dist. 9—North Texas	6	70.0	3,010,000	2	9.0	2,100,000	2	6.0	630,000	10	85.0	5,740,000
Dist. 10—Panhandle	4	25.2	2,298,000	1	10.0	480,000	...	....	.....	5	35.2	2,778,000
Total State	82	1,009.2	87,755,000	43	958.8	139,175,000	13	259.5	29,425,000	138	2,227.5	256,355,000

Great Strides Made in Conserving Casinghead Gas

OIL companies operating in Texas are vigorously engaged in a $256 million conservation program that is making remarkable progress in saving and utilizing vast amounts of casinghead gas which otherwise would be wasted. The casinghead gas-conserving program, inaugurated immediately after the end of the war, has attained particularly impressive levels during the last two years, and currently is being expanded on a more extensive scale than ever before.

As a result, the utilization of casinghead gas has grown tremendously throughout the state during the past three years. This is especially significant, since this type of gas, which is produced by oil wells, long has constituted a complex conservation program and consequently heretofore frequently has been burned in flares. Furthermore, present large-scale construction of additional necessary facilities assures that even more important strides will be made in the immediate future. Unquestionably, this is one of the most significant advancements in the history of the conservation of a natural resource.

Big Building Program

A late December survey revealed that 82 casinghead gas conservation projects were completed in Texas between the close of the war and the end of 1948, 43 additional projects currently are under construction, and authorization has been given for building 13 others. When all these projects are completed in 1949 and 1950, a total of 138 casinghead gas conservation projects will have been built in the state since September, 1945, at a cost exceeding $256 million.

These new postwar plants, when all are completed, will utilize nearly 2¼ billion cubic feet per day of casinghead gas which otherwise would be flared. The survey shows that slightly more than 1 billion cubic feet of casinghead gas was being utilized daily in those newly completed projects which were operating by the end of 1948. This is in addition to using large amounts of natural gas produced by gas wells. Nearly 1¼ billion additional cubic feet of casinghead gas will be conserved daily when projects now under construction and authorized are finished in the next 18 months. Actually, this volume will be enlarged above this figure, since plans for building other new plants are being announced every month.

History's Greatest Conservation

However, even at present known levels, the postwar period marks the greatest expansion of casinghead gas conservation in history. The nearly 2¼ billion cubic feet which postwar projects will be using by 1950 is more than twice the volume that was being utilized at the end of the war. Only a little more than 1 billion cubic feet of casinghead gas was being used daily in Texas in September, 1945, although the first such plant was constructed in 1915.

This conservation program attained especially great heights during 1947 and 1948, but present construction rates assure that the volume of casinghead gas which will begin to be conserved during 1949 will far exceed either of the two previous record breaking years. The 43 projects under construction at the end of 1948 will use 959 million cubic feet of casinghead gas per day when completed. Of this number, 38 are scheduled for completion in 1949, and these will utilize 640 million cubic feet of casinghead gas daily.

In addition, there are the 13 other projects which have been authorized but on which construction work has not been started. Of these, 9 that will use 164 million cubic feet of casinghead gas daily are scheduled to go into operation during 1949.

Thus, it is expected that 47 new projects will be placed in operation during 1949, and that they will utilize 804 million cubic feet of casinghead gas per day. Utilization of 804 million cubic feet of additional casinghead gas during 1949 will compare with an increase of 484 million cubic feet during 1948, with 376 million cubic feet during 1947, and with 138 million cubic feet during 1946.

Casinghead Gas Only

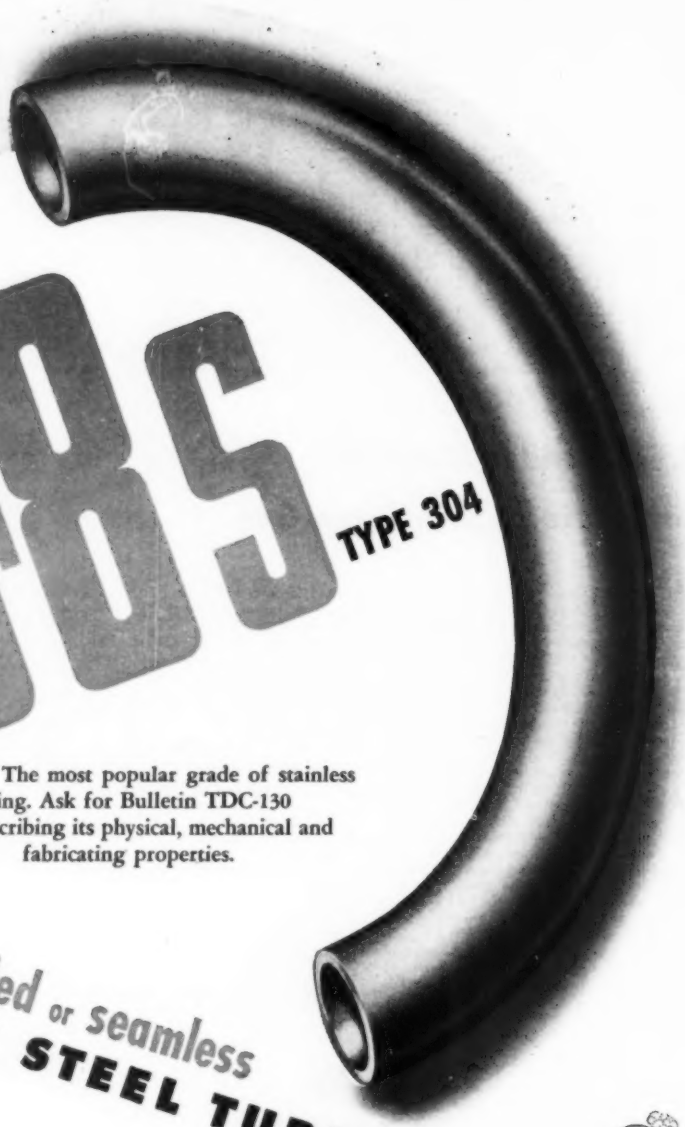
All figures used in this article are for casinghead gas alone, gas produced by gas wells having been excluded from the survey. A number of additional plants processing only gas produced from gas wells have been constructed in Texas since the war, and almost without exception all the 138 casinghead gas projects built, now building or to be constructed also will utilize large quantities of gas-well gas. In fact, many of the plants will process much greater volumes of gas-well gas than of casinghead.

The survey was purposely confined to casinghead gas, because the conservation of this gas encounters numerous serious difficulties as compared with gas-well gas which is produced only in response to market requirements or other needs. Even plant costs were allocated on the relationship of casinghead gas used to the volume of gas-well gas utilized. Hence, much larger quantities of gas are being processed in these new plants than shown and their total cost is a great deal more than indicated.

The size of the present casinghead gas conservation program is sufficient to make it extraordinarily noteworthy, but only when consideration also is given to the numerous complex problems which must be overcome can its significance really be appreciated in the proper light. The industry, of course, is acutely aware of the problems, but they bear repeating because a lack of understanding on the part of the public has too often brought severe accusations of waste.

Fundamentally, the fact that casing-

Answers MOST corrosion problems



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head gas is produced by oil wells makes its conservation a real problem. Its production cannot be controlled except to a very limited measure without also restricting the output of crude needed to make gasoline, fuel oil and other essential petroleum products. Unfortunately, it cannot be stored aboveground as can oil. So casinghead gas must be conserved as it is produced, and therefore its conservation necessarily becomes one of proper utilization.

In some cases it is possible to conserve casinghead gas by returning the gas to the producing or some other subsurface formation as rapidly as it is produced. However, in many cases this is not necessary from the standpoint of oil recovery operations, and in most instances it is not economically practical. Such operations require the installation of expensive compressor equipment to raise the pressure of the gas above that of the formation to which it is returned. Oil companies do not get any financial revenue from the gas returned to producing formations, but they do hope to increase the recovery of oil and, moreover, they are not wasting the gas. This plan is being used extensively in the present program.

Marketing Difficulties

Casinghead gas is produced in relatively small amounts from thousands of wells scattered over a tremendous area, many remote from market. Even within a single field an extensive pipe line system is needed to gather the gas from individual wells.

Furthermore, it is usually impractical and uneconomical for a single operating company in a field to arrange for the utilization of all the casinghead gas it produces. Ordinarily, it is necessary for several operators to work out a joint program in order to form a project which is economically feasible and also to make sufficient gas available to find or attract a market. Although for years it has been possible to find sufficient markets for only a part of all the casinghead gas produced, producers long have been stripping the liquefiable contents from a large portion of the casinghead gas that contains sufficient liquids to justify processing. In September, 1948, more than 1½ billion cubic feet of casinghead gas was being processed for its liquid content daily in the state of Texas.

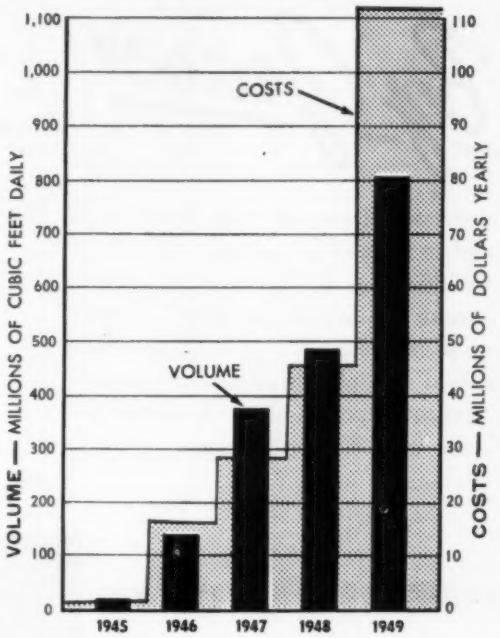
The only market possibilities for casinghead gas are gas pipe lines which will carry it to distant consuming markets, or in a few cases to nearby carbon black, chemical or other local industrial plants. Oil fields usually are remote from these market possibilities, but even when located conveniently many problems still exist. The constant rate at which casinghead gas must be produced and handled does not fit into the picture of widely varying consumer demands which occur with every change in the weather. Casinghead gas normally is available only at low pressures; consequently it must be gathered and compressed to boost its pressure sufficiently to put it into a pipe line.

Casinghead gas conservation operations require an enormous capital investment on which relatively little financial return can be realized under present conditions. Even with recently improved prices, partly as a result of building pipe lines to the northern and eastern areas of the U. S. and the entry of additional industry into the state, casinghead gas still brings comparatively small financial return because such high costs are necessary in effecting its utilization. Due to an excessive supply of gas, only in recent years have Texas operators begun to receive as much as 5 cents per thousand cubic feet for their casinghead gas. In 1943, the average rate for oil field gas was only 2½ cents per thousand. The average oil well in Texas produces 18,000 to 30,000 cubic feet of casinghead gas per day, and even at the new higher rate of 5 cents per thousand this is only 90 cents to $1.50 per day per well gross income from which heavy conservation costs must be deducted. Therefore, saving of casinghead gas in many fields is impractical at present-day gas prices.

The Texas Railroad Commission has displayed a keen interest in the casinghead gas conservation problem. A November order shut in 17 fields which were said to be wasting excessive quantities of casinghead gas. Some operators have contested this action in the courts on the ground that the shutdown orders were unreasonable because projects for utilizing the gas were in progress in some of the fields affected and sufficient time had not been allowed to develop plans in other cases.

As a whole, however, the industry and the commission have worked together on this important problem. The prompt inauguration of a casinghead gas conservation program following the war and the extensive scale to which it has grown demonstrate how well the industry has responded, and show that oil operators, together with the Railroad Commission, recognize the obligation to save casinghead gas whenever feasible and practical.

Annual Costs and Utilization Volumes of Texas Casinghead Gas Conservation Projects Completed 1945-1948 and Scheduled for 1949



	Number of Projects	Daily Volume of Casinghead Gas Utilized (Mil. Cu. Ft.)	Approximate Cost for Casinghead Facilities
Completed in 1945	2	12.0	$ 275,000
Completed in 1946	18	137.6	14,992,000
Completed in 1947	32	375.7	27,693,000
Completed in 1948	30	483.9	44,795,000
Total Completed 1945-1948	82	1,009.2	87,755,000
To be completed in 1949	47	804.3	111,945,000
To be completed in 1950	9	414.0	56,655,000
Grand Total	138	2,227.5	256,355,000

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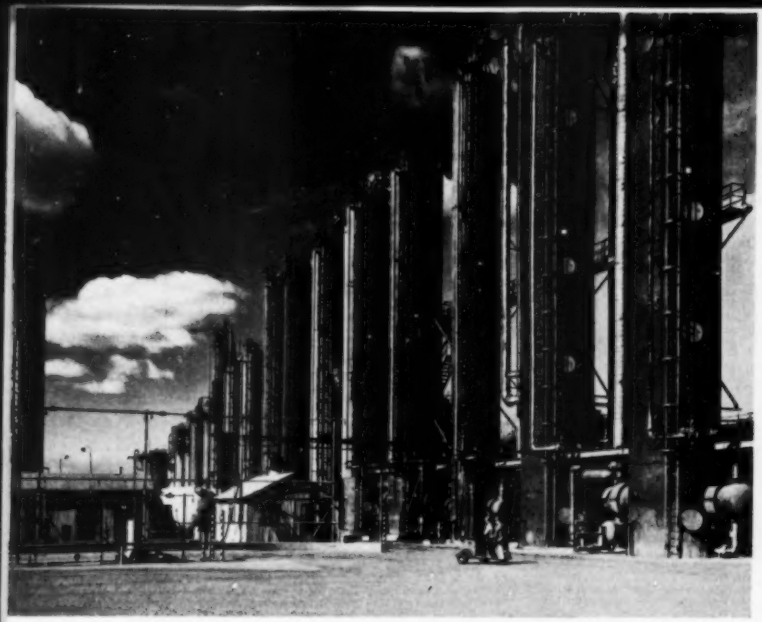


Fractionating Facilities for LPG Production.
—Photo Courtesy Phillips Petroleum Company

Liquefied Petroleum Gas Sales Continue Gains in 1948

K. W. RUGH and E. O. MATTOCKS
Phillips Petroleum Company, Bartlesville, Okla.

DURING 1948 the liquefied petroleum gas industry continued the steady growth which it has consistently shown during the past decade. In spite of various obstacles placed in its path the rate of growth has been reasonably uniform. It is estimated that during 1948 the total volume of liquefied petroleum gas marketed will reach a total of 2600 million gallons. This represents a 29.5 percent increase over the volume sold in 1947. The increase in 1948 in marketed LPG over that marketed in 1947 was greater than the total quantity of liquefied petroleum gas marketed during 1942. The 1948 volume is equal to 24 percent of the total LPG marketed since 1930.

The estimated volume of LPG sold for domestic purposes in 1948 is 1540 million gallons. This represents an increase of 33.9 percent over that consumed for the same purpose in 1947. The total quantity consumed for domestic purposes in 1948 is greater than the total quantity of LPG sold for all purposes in 1946, just two years prior. The large demand for this product for homes, farms, institutions and commercial establishments located beyond the gas mains is clearly indicated. This domestic requirement is made up of two different demands. The first results from new consumers added during the year who previously have used other types of fuel or whose fuel requirements represent an entirely new demand, such as for a new home. The other demand results from the increased usage by consumers who have had LPG installed for some time.

It is estimated that better than 25 percent of the gas ranges produced in 1948 went into the LPG market. The demand for LPG automatic water heaters and refrigerators continues to increase. Space heating with LPG is enjoying a greater demand than ever. All of these demands are the result of the satisfaction which consumers are enjoying from the use of LPG. It is estimated that there are now about 5½ million homes using LPG. It is also estimated that one-third of these use LPG for space heating as well as for the other household purposes. There are presently installed more than 3000 bulk plants, a number which is about equal to the number of counties in the United States.

Used as Standby

The amount of LPG marketed for industrial and miscellaneous uses during 1948 is estimated at 280 million gallons. One of the most rapidly growing uses for LPG by industrial plants is for standby to other fuels, generally manufactured or natural gas. Greatly increased domestic and commercial space heating requirements have resulted in demands that frequently exceed the capacity of natural gas transmission lines or that of manufactured gas producing plants. To meet this increased demand it has been necessary to force more and more industrial gas consumers to accept a lesser amount of gas during the peak load periods. To insure against an interruption of gas supply, a large number of industries have installed LPG as a standby fuel. These installations furnish varying percentages of the total gas load, in many instances supplying complete replacement with mixtures of LPG and air. This replacement with LPG assures continuity of production with a minimum of concern over burner and furnace operation.

Gas Manufacturing Installations

The use of LPG in gas manufacturing installations continues its rapid increase. It is estimated that 280 million gallons were used in 1948 for this purpose. This is an increase of 65.4 percent over 1947. The increased distribution of natural gas throughout the country has in many instances resulted in excessive space heating demands during the winter months. LPG is used to a great extent to augment both natural and manufactured gas supplies during peak loads. A controlled amount of LPG and air may be mixed directly with manufactured gas without encountering burner operating difficulties, but the reforming of LPG to produce a substitute gas is permitting even greater quantities to be used. LPG is used generally not only to feed the reforming units but also to enrich the produced gas to the desired heating value. Large proportions of LPG and air mixtures may be mixed with natural gas or in some instances may replace natural gas completely without causing any unusual burner operating difficulties. The installation by utilities of large new standby units or additions to present installations has continued throughout 1948. Almost 400 towns are now served with LPG exclusively.

The volume of LPG used for chemical manufacture is one of the most difficult to estimate. LPG is used as an intermediate product which is processed to some other product, the latter serving as an ingredient of a required chemical. Large quantities of liquefied petroleum gases in the gaseous form are furnished to chemical companies through pipe lines directly from the source of production. In a number of cases, these gases are composed largely of olefins—unsaturated hydrocarbons. It is estimated that 500 million gallons will be used in 1948 for chemical manufacturing purposes. This represents an increase of 20.7 percent over 1947.

Consumer Storage Increased

During 1948 great results have been accomplished in increasing the storage capacity at consumers' installations. The industry has found this to be essential in order to provide gas for house heating during peak demands when requirements exceed production. Transportation facilities, both tank car and transports, have been increased in adequate number to handle the increased amount of LPG marketed. The pipe line movement of LPG to the domestic, indus-

Marketed Production of Liquid Petroleum Gas

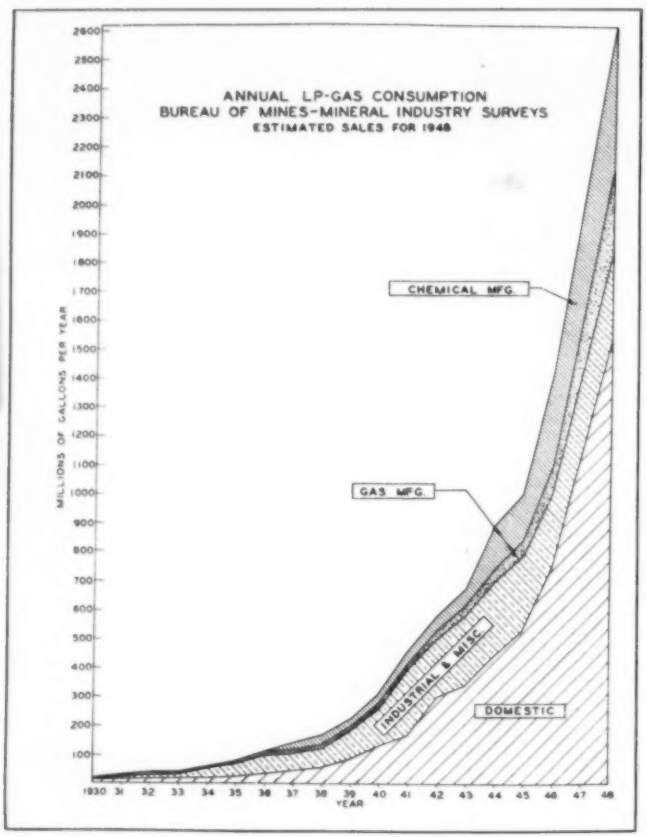
YEAR	TOTAL SALES		DISTRIBUTION—1000 Gallons							
	Gallons in Thousands	Percent Increase	Domestic[1]	Percent Increase	Ind. and Misc.[2]	Percent Increase	Gas Mfg.	Percent Increase	Chemical Mfg.	Percent Increase
1922	223									
1923	227	24.4								
1924	376	36.0	Sale of Liquid Petroleum Gas Confined Primarily to Bottled Gas Business Prior to 1928							
1925	404	7.2								
1926	465	15.2								
1927	1,091	134.6								
1928	4,523	314.6	2,600		400		1,500			
1929	9,931	119.6	5,900	126.9	1,500	275.0	2,500	66.7		
1930	19,017	81.4	11,800	100.0	2,200	46.7	4,000	60.0		
1931	28,770	59.7	15,295	29.6	7,172	226.0	6,303	57.6		
1932	34,115	18.6	16,244	6.2	8,167	13.9	9,703	53.9		
1933	38,931	14.1	16,626	2.3	13,987	71.3	8,318	—14.3		
1934	56,427	44.9	17,681	6.3	32,448	132.0	6,298	—24.3		
1935	76,855	36.2	21,380	20.9	47,894	47.6	7,581	20.4		
1936	106,652	38.8	30,014	40.4	67,267	40.4	9,371	23.6		
1937	141,400	32.6	40,823	36.0	62,610	[3]	11,175	19.3	26,792	
1938	165,201	16.8	57,832	41.7	62,694	0.0	12,386	10.8	32,299	20.5
1939	223,580	35.3	87,530	51.4	93,723	49.4	15,435	24.6	26,892	—16.7
1940	313,456	40.2	134,018	53.1	124,482	34.5	20,285	31.4	34,671	29.0
1941	462,852	47.7	220,722	64.7	172,669	38.6	25,255	24.5	44,206	27.5
1942	585,440	26.5	303,857	37.3	197,149	14.3	31,366	24.2	53,038	20.0
1943	675,233	15.3	344,962	13.7	237,396	20.2	37,518	19.6	55,356	4.4
1944	898,071	33.0	445,617	29.0	254,590	7.3	43 879	22.3	151,985	175.0
1945	1,067,979	19.0	533,262	19.7	256,577	0.8	53,849	17.4	224,291	47.5
1946	1,410,370	32.1	758,466	42.2	253,745	—1.1	80,660	61.0	311,499	38.8
1947	2,008,262	42.4	1,150,538	51.7	274,125	8.0	169,332	95.4	414,267	33.0
1948	2,600,000	29.5	1,540,000	33.9	280,000	2.1	280,000	65.4	500,000	20.7

[1] Household use plus other requirements by these customers such as irrigation pumping, tractor fuel, flame weeding, chicken brooding and similar uses. Included also is LPG sold by domestic distributors but used for industrial purposes, internal combustion engine fuel and for gas manufacturing purposes.

[2] Includes LPG sold for fueling internal combustion engines.

[3] Not comparable due to segregation of chemical manufacturing.

REMARKS: In this table total sales for all years except 1948, were obtained from U. S. Bureau of Mines reports. Distribution for the years 1931 to 1947, inclusive, was obtained from the same source. All other volumes were estimated by the writers. The total sales volume includes all LPG (propane, butane and propane-butane mixtures) when sold as such. Until 1944 the sale of pentane when sold for any purpose other than motor fuel blending was included. Since then it has been excluded. It does not include butane when blended with heavier petroleum fractions for motor fuel purposes. Intercompany sales transactions such as purchases of LPG by one company from other companies and resold as LPG have been eliminated in order to avoid duplication of sales figures. The data do not reflect sales of LPG used directly by the producer at the point of production for fuel polymerization, solvent de-waxing, etc. Neither do the figures include sales of hydrocarbons to plants manufacturing synthetic rubber or aviation gasoline or their components.


ANNUAL LP-GAS CONSUMPTION
BUREAU OF MINES-MINERAL INDUSTRY SURVEYS
ESTIMATED SALES FOR 1948
CHEMICAL MFG.
GAS MFG.
INDUSTRIAL & MISC.
DOMESTIC
MILLIONS OF GALLONS PER YEAR
YEAR
1930 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

trial and utility markets is increasing and during the year a major marketer completed a finished petroleum products pipe line through which propane and butane are transported.

New sources of production of liquefied petroleum gas together with the enlargement of existing producing facilities have increased the supply of LPG during the past year to keep pace with the increase in demand.

The acceptance, by most of the states in the United States, of the National Fire Protection Association Liquefied Petroleum Gas Code which is generally referred to as the National Board of Fire Underwriters' Pamphlet No. 58, *Standards for the Design, Installation and Construction of Containers and Pertinent Equipment for the Storage and Handling of Liquefied Petroleum Gases as Recommended by the National Fire Protection Association*, indicates the general acceptance of this code as the basis for standards of safety. The code has been used in whole or in part as the basis of many state and local laws, rules and regulations. Various provinces in Canada are considering it for adoption as provincial regulations. The National Fire Protection Association during 1948 developed a code for the used of LPG by utilities.

While the unabated increased demands for LPG require major readjustments in all phases of the industry, every indication points to the ability of this industry to meet the challenge of these demands.

"News Gatherer" Named

General Petroleum Corporation has appointed Don Sweeney, veteran journalist, to the newly-created position of "news gatherer and disseminator." He will be located in the home office in Los Angeles.

Sweeney served as a civilian technician overseas during World War II for the Army Air Forces.

theme for service

c
construction

f
fabrication

e
engineering

d
design

A working harmony is not achieved overnight—it is the result of working together for many years on many projects.

Foster Wheeler engineers have collaborated with petroleum refiners for more than 25 years in the design, engineering, fabrication and construction of over 400 petroleum processing units.

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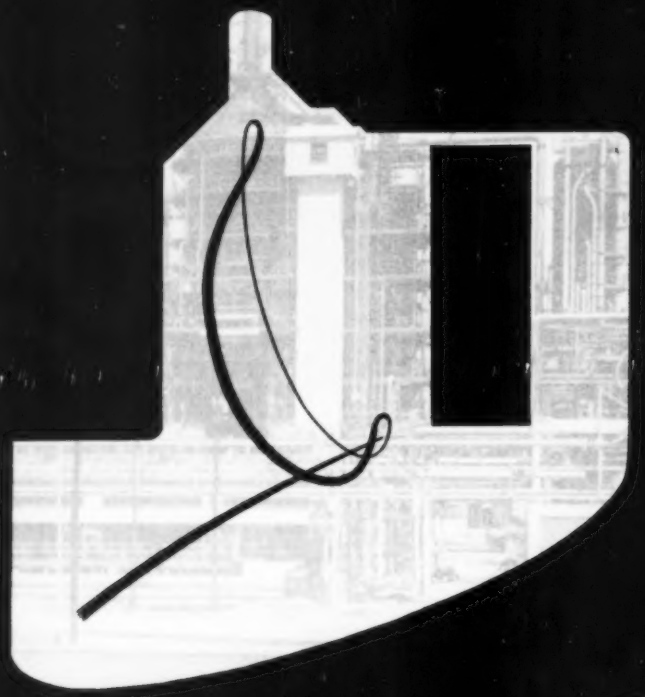
process rhythm



A smooth-running unit — a unit in balance — is one in which all parts are functioning in rhythm. This is possible only when the unit is designed 'right' and built 'right'.

Rhythm (as symbolized by the catalyst flow pattern in the illustration) is an achievement peculiar to the experienced professional . . . to the experienced contractor who knows just what qualities in the basic functions of design, engineering, fabrication and construction produce "process rhythm".

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PROCESS UNITS
COMPLETE PETROLEUM REFINERIES
and
CHEMICAL PLANTS

THE MONTH IN THE INDUSTRY

Du Pont To Build Chemical Plant Near Victoria Texas

E. I. Du Pont de Nemours and Company, Inc. has purchased one tract and has exercised an option on another in the Guadalupe River Valley, near Victoria, Texas. A chemical plant to make chemical intermediates for nylon will be constructed on the 1700-acre site.

The ammonia department has concluded preliminary engineering of the tract. E. D. Ries, general manager of the department, expects the company to begin detailed design, ground preparation and similar projects early in 1949.

E. R. Wagner Heads New Stanolind Gasoline Plant

E. R. Wagner has been named plant superintendent of Stanolind Oil and Gas Company's new Slaughter natural gasoline plant near Levelland, Texas. The plant is one of four to be completed by Stanolind early next year. The other three are Elk Basin, Powell, Wyo.; Stano, Ulysses, Kan., and Burnell-North Pettus, Pettus, Texas.

Slaughter plant, in the Slaughter Field, 13 miles southwest of Levelland, is expected to be completed next March. It will process 90 million cubic feet of gas from the field per day, and will produce 80,000 gallons of gasoline and 100,000 gallons of butane and propane each day.

Wagner goes to the Slaughter plant from Stanolind's Salt Creek gasoline plant at Midwest, Wyo., where he has been plant superintendent since July, 1943. He studied at South Dakota School of Mines and the University of Wyoming, joining Stanolind in 1933. He served in various operating capacities until being made plant superintendent at Salt Creek.

Calendar of Meetings

JAN. 1949 27	Society Automotive Engineers, (Fuels and Lubricants), New York, Engineering Societies Building.
FEB. 13–17	American Institute of Mining and Metallurgical Engineers, Annual Meeting, San Francisco, Fairmont Hotel.
28 to MAR. 4	American Society for Testing Materials, Spring Meeting and ASTM Committe Week, Chicago, Hotel Edgewater Beach.
MAR. 1– 2	Wisconsin Petroleum Association, Annual Convention, Milwaukee, Schroeder Hotel.
6–10	American Institute of Chemical Engineers, Regional Meeting, Los Angeles.
7–10	Manufacturers Standardization Society of the Valve and Fittings Industry, New York, Commodore Hotel.
7–10	National Association of Corrosion Engineers, Annual Convention, Cincinnati.
14–17	Chicago Technical Societies Council, Annual Chicago Production Show, Chicago, Hotel Stevens.
24–25	New England Gas Association, Boston, Statler Hotel.
27 APRIL 1	American Chemical Society, Division of Petroleum Chemistry, Spring Meeting, San Francisco.
28–30	Western Petroleum Refiners Association, San Antonio, Plaza Hotel.
29 APRIL 1	Nineteenth Annual Safety Association, Boston, Statler Hotel.
APRIL 4– 5	Industrial Accident Prevention Association, Toronto, Canada, Royal York Hotel.
4– 7	American Petroleum Institute, Refining Division, Mid-Year Meeting, Houston, Shamrock Hotel.
11–12	American Institute of Electrical Engineers, New York, Statler Hotel.
11–13	Midwest Gas Association, Annual Convention, Des Moines, Hotel Ford Des Moines.
11–13	American Society of Lubrication Engineers, Annual Meeting, New York, Pennsylvania Hotel.
11–13	National Association of Corrosion Engineers, Cincinnati, Netherlands-Plaza Hotel.
11–15	Western Metal Congress and Exposition, Los Angeles, Shrine Civic Auditorium.
12–14	Southwestern Gas Measurement Short Course, Norman, University of Oklahoma.
APRIL 1949 13–15	National Petroleum Association, Cleveland, Hotel Cleveland.
18–20	Midwest Power Conference, Annual Meeting, Chicago, Hotel Sherman.
20–22	Southern Gas Association, Annual Convention, Biloxi, Buena Vista Hotel.
20–22	Natural Gasoline Association of America, Fort Worth, Texas Hotel.
28	Society of Automotive Engineers, New York, Engineering Societies Building.
MAY 2– 4	Independent Petroleum Association of America, Mid-Year Directors Meeting, New Orleans.
2– 4	The American Society of Mechanical Engineers, Spring Meeting, New London.
8–12	American Institute of Chemical Engineers, Regional Meeting, Tulsa.
9–10	American Gas Association, Natural Gas Department, Spring Meeting, French Lick, French Lick Springs Hotel.
9–11	Liquefied Petroleum Gas Association, Annual Convention and Trade Show, Chicago, Palmer House.
12–13	Instrument Society of America, Annual Spring Meeting, Toronto, Canada, Royal York Hotel.
12–13	American Gas Association, Executive Conference, San Francisco, Fairmount Hotel.
16–19	National Fire Protection Association, San Francisco, Fairmont Hotel.
17–19	Pennsylvania Gas Association, Annual Convention, Wernersville, Galen Hall.
23–25	American Gas Association Production and Chemical Conference, New York, Hotel New Yorker.
26	Society of Automotive Engineers, Diesel Engine, New York, Engineering Societies Building.
26–27	The Natural Gas and Petroleum Association of Canada, Annual Meeting, London, Ontario, Hotel London.
JUNE 5–10	Society of Automotive Engineers, Summer Meeting.
16–20	Canadian Gas Association, Annual Convention, Lake of Bays, Ontario, Canada, Bigwin Inn.
24–25	Michigan Gas Association, Annual Convention, Mackinac Island, Grand Hotel.
27–30	The American Society of Mechanical Engineers, Semi-Annual Meeting, San Francisco.
27 JULY 1	American Society for Testing Materials, Annual Meeting, Atlantic City, Haddon Hall, Hotel Chalfont.

J. W. Sandberg Becomes Phillips Process Engineer

J. W. Sandberg has joined the perco division of the chemical products department of Phillips Petroleum Company. He will serve as process engineer.

Sandberg

Coming to this country after spending over six years in Trinidad, British West Indies, Sandberg was associated with Trinidad Leasehold, Ltd., at its refinery.

A 1940 graduate of McGill University, Montreal, Canada, he holds a bachelor of engineering degree in chemical engineering. He is a former member of the Engineering Institute of Canada.

Stanolind Division Names James Smith as Attorney

James K. Smith has been named division attorney for Stanolind Oil and Gas Company at Fort Worth, Texas. Associated with him will be Ernest B. Helsley, formerly employment supervisor in the company's Tulsa general office. Walter P. Dornaus, attorney in the Fort Worth department, will transfer to the Tulsa general office.

For the past year and a half Smith has been associated with Armstrong, Barker, Bedford and Smith at Galveston, Texas. Previously he served in the United States Attorney's office, Houston. He received his bachelor of science degree in commerce from University of North Carolina and his LL.B. from the Washington (D. C.) College of Law.

Dornaus holds a bachelor of arts degree from Illinois Wesleyan University and his LL.B. from University of Oklahoma. He has been in the law department at Fort Worth since 1944. Helsley joined Stanolind in 1937 and was in the Fort Worth office until 1943 when he transferred to Tulsa as employment supervisor. He received his law training at American Law School, Chicago.

Stanolind Promotes Three Plant Superintendents

Stanolind Oil and Gas Company has transferred and promoted three plant superintendents in the Texas-Louisiana Gulf Coast area.

E. J. Yocom, superintendent at the South Jennings recycling plant, Jennings, La., was transferred to the Hastings gasoline plant, Alvin, Texas. He succeeds C. W. Ward, who has been made superintendent of Stanolind's new Elk Basin plant, Powell, Wyo.

H. W. Jones, plant foreman at Superior refinery, Vivian, La., was made superintendent at the South Jennings plant, succeeding Yocom.

V. E. O'Donnell, plant foreman at La Rosa recycling plant, Woodsboro, Texas, was promoted to superintendent

THE MONTH . . .

of the Luby gasoline plant, Bishop, Texas. He succeeds H. J. Olinger, deceased.

With Stanolind since October, 1933, Yocom served as plant chemist and plant foreman at the South Jennings plant before being made superintendent there. He has a B.S. degree in chemical engineering from the University of Illinois.

Jones has been at the Superior refinery since joining the company in 1938. He was made plant foreman in April, 1947. He has a B.S. degree in chemical engineering from Iowa State College.

O'Donnell was plant engineer at the South Jennings plant for nearly three years before going to La Rosa as plant foreman in May, 1947. He has been with Stanolind since November, 1943. He attended Hibbing (Minn.) Junior College, and the University of Minnesota, and has an engineering degree from the University of Texas.

Shell Names P. E. Lakin Executive Vice President

P. E. Lakin early this month was appointed executive vice president of Shell Oil Company. In his new capacity he will serve as Shell's senior representative on the Pacific Coast, with headquarters in San Francisco. Until his present appointment, he was vice president in charge of marketing, New York.

Lakin

Lakin began his career with Shell as a clerk in Seattle in 1915, after completing his education at the University of California. He spent two years in France with the 96th Aero Squadron during World War I, then returned to enter Shell's marketing department, where he served in several positions. In 1933 he was appointed sales manager of the Mid-Continent territory with headquarters in St. Louis, and three years later he became vice president in charge of marketing. Since 1942 his headquarters have been in New York and in 1945 he was elected to the board of directors.

Shale-Oil Product Patents Indexed by Bureau of Mines

All American and foreign patents on shale-oil products have been listed in an index by the Bureau of Mines. Patents on record in the U. S. Patent Office up to January 1, 1945, are included with an illustrated short description of each claim.

To be followed in about a year by a companion volume listing patents on oil shale, the present Bulletin 4319 may be obtained from Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 75 cents per copy.

L. W. Moore Becomes Head Of Pan American Refining

L. W. Moore on January 1 became president of Pan American Refining Corporation and Mexican Petroleum Corporation of Georgia. D. J. Smith, president of Pan American Petroleum & Transport Company, the parent company, while remaining chairman of the board, has resigned as president of the two refining companies after serving in this capacity for four years. The two companies operate refineries in Texas, Georgia and Maryland.

Moore

Moore was graduated from Massachusetts Institute of Technology with a B.S. degree in 1933, and immediately started his career in the Research department of Standard Oil Company (Indiana) at Whiting, Ind. Joining Pan American Petroleum & Transport Company, New York, in 1935, Moore 10 years later was appointed manager of research of Pan American Refining Corporation. In 1947 he was appointed manager of manufacturing and was elected a director of Pan American Refining Corporation, Pan American Production Company, Pan American Gas Company, Pan American Pipe Line Company and Mexican Petroleum Corporation of Georgia.

In his new capacity Moore will have charge of the company's refining activities but will continue as a director of the other companies. He will maintain his present office in the Chanin Building, New York.

Emile E. Soubry Named to Standard Directors Board

Emile E. Soubry, coordinator of marketing of Standard Oil Company (New Jersey) has been elected a member of the Board of Directors effective January 1, 1949. Having spent all of his working years with Standard and its affiliates in the United States and abroad he started as a clerk in the shipping department of Anglo American Oil Company, Ltd., in London, England, in 1911.

In the early 1930's Soubry studied marketing conditions, oil field and refinery operations in the United States. Later he received a special marketing assignment to Australia and New Zealand, following which he was resident in Europe as adviser to the various Esso European marketing companies.

Just before World War II Soubry was appointed chairman of the Anglo American Oil Company, and during the war served on the British Oil Trade Committee, and later as liaison between that Committee and the United States government. On his release from that work in 1943 he was appointed foreign marketing coordinator for Standard and has directed all marketing operations since October, 1947.

Combined Service Offered

Process Industries Engineers, Inc., Pittsburgh, is offering a service to the chemical industry and processing field which will integrate two complementary services. Equipment of nationally known manufacturers whose engineered applications are satisfactory will be sold. The company will also design and fabricate equipment where special designs are necessary.

Specializing in the fields of impregnation, drying, vulcanization, fumigation and inter-related unit process operations which include material storage, handling, fluid movement, mixing and agitation and reduction and separation, the company will design, contract for fabrication, inspect during manufacture and render technical assistance during plant installation and initial stages of operation.

French Refineries Average 200,000 Barrels Per Day

Capacity of France's refineries has reached almost 200,000 barrels daily, a figure not expected until 1951. The government now has set a goal of 375,000 barrels daily for 1952-53. At the present rate of growth, the refineries should be processing about 300,000 barrels daily by that time.

Concentration since the war has been on expanding quantity with little concern about the quality of the products. Gasoline octane rating has been kept about 65, which is about the lowest in Europe.

Until 1953 French motorists will be allowed 25 percent less gasoline than they received in 1938, when daily output was 162,000 barrels. The increased production of oil products will be used for industrial, commercial transport and agricultural purposes.

B. N. Darbyshire Joins Moore and Charlton Group

Bernard N. Darbyshire has joined the Moore and Charlton group of companies. He will manage the London office of Harold Moore and Partners (Engineers) Ltd. and will represent Moore and Charlton, petroleum consultants.

Previously he was petroleum economist in the trade relations department at the head office of Shell Petroleum Company, Ltd. in London. Following his graduation from the Honours School of Economics and Political Science at Dublin University, Darbyshire served with the Naval Intelligence Division. In 1946 he joined the Royal Dutch Shell group. Subsequently he transferred from Anglo-Saxon Petroleum Company, Ltd., to Shell Petroleum.

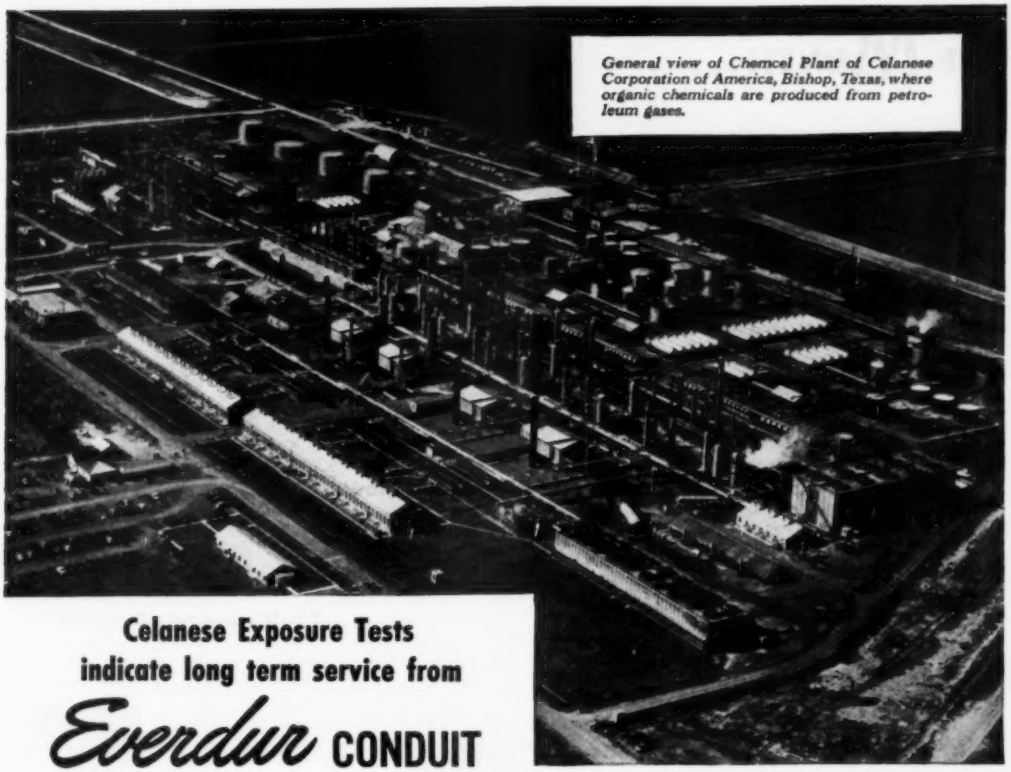
Conoco Goes on Stream

Capacity of Continental Oil Company's Denver refinery has almost doubled since going on stream late in November. A $5,800,000-enlargement program launched in June, 1947, added catalytic cracking, a new vapor recovery and gasoline stabilization unit, catalytic polymerization and enlarged liquified petroleum gas facilities.

Mahoney Joins Snell

John J. Mahoney has been appointed director of engineering of Foster D. Snell, Inc., chemists and engineers, New York.

Mahoney was graduated, 1940, in chemical engineering by the College of the City of New York and he subsequently pursued his studies under a graduate fellowship at the University of



General view of Chemcel Plant of Celanese Corporation of America, Bishop, Texas, where organic chemicals are produced from petroleum gases.

Celanese Exposure Tests indicate long term service from *Everdur* CONDUIT

ELEVEN test specimens of Everdur* Rigid Electrical Conduit, ¾″ nominal size, mounted on top of cooling towers of the Chemcel Plant at Bishop, Texas, graduated with honors from a 95-day course in compound exposure.

These 2″ long test sections were exposed to sunlight, continuous water vapor spray, plant fumes, plant Northeast and Southwest winds and a temperature range of 32° F. to 87° F.

Examination showed no pitting of samples and an average corrosion rate of .000395 i.p.y. "During the test," states the Metallurgical Laboratory report, "the surface of the specimens became coated with a thin, black corrosion product film which would be in no way detrimental in the service intended."

"Everdur Conduit would," the report continues, "at the rates determined, last indefinitely in service as electrical conduit in the locations tested."

Everdur Copper-Silicon Alloy Conduit possesses high strength, is non-magnetic, workable and weldable. It is available in two wall thicknesses: rigid conduit (RC) in nominal sizes from ¼″ to 4″ inclusive; and the thinner walled electrical metallic tubing (EMT) in nominal sizes ⅜″ to 2″ inclusive. Complete lines of fittings . . . connectors, couplings, outlet boxes, etc. . . . are available in Everdur Alloys from leading manufacturers. 66284

*Reg. U. S. Pat. Off.

ANACONDA

Everdur

ELECTRICAL CONDUIT

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

THE MONTH . . .

Pennsylvania. He comes to the Snell organization from the Colgate-Palmolive-Peet Company. His previous connections were with Burns & Roe, consulting process engineers, Selas Corporation of America, and the Philadelphia Navy Yard.

Monsanto Makes Changes In Administrative Offices

Monsanto Chemical Company's executive committee has been increased to five members, Osborne Bezanson and R. R. Cole, vice presidents, having been added to the present three-man committee composed of Edgar M. Queeny, chairman of the board of directors; William M. Rand, president; and Dr. Charles Allen Thomas, executive vice president and technical director.

W. G. Krummrich, assistant general manager of the organic chemicals division, will succeed Bezanson as acting general manager of the division.

Succeeding Cole, formerly general manager of the phosphate division, is John Christian, manager of the company's plant at Monsanto, Tenn.

Francis J. Curtis, vice president and secretary of the executive committee, will also act as sales coordinator.

Dr. Carroll A. Hochwalt, vice president in charge of the company's central research department, will assume responsibility for the coordination of the company's research and development activities. Associate director, Howard K. Nason, will serve as acting director of the central research department.

George Mitchell Appointed Head AGA Convention Group

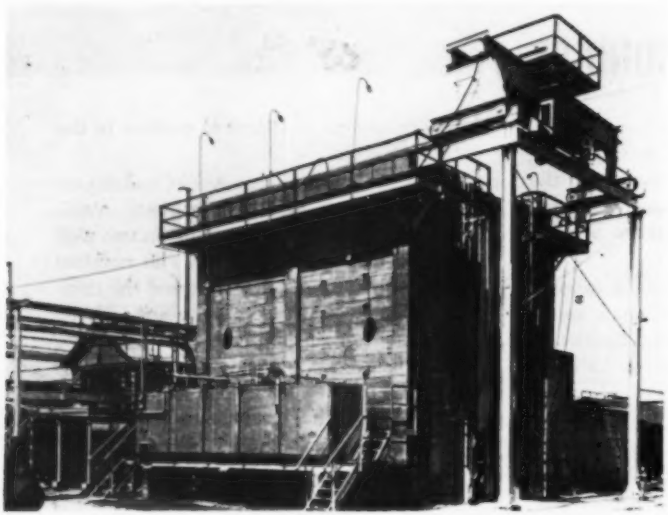
George F. Mitchell, president of The Peoples Gas Light and Coke Company, Chicago, has been appointed chairman of the 1949 convention committee of the American Gas Association. F. X. Mettenet, vice president of The Peoples Company, will serve as vice chairman of the committee.

This committee directs over-all arrangements of the annual convention of the association. This year the meeting will be held October 17-20 in Chicago.

Tide Water Adds Houdriflow

Tide Water Associated is expanding its Drumright, Okla., refinery with a houdriflow catalytic cracking unit, a new 6700-barrel daily unit, being installed by Houdry Process Corporation. Tentative schedule for completion is late 1949 or early 1950.

New Synthetic Alcohol Process by Esso



Reactors operating at 3000 psi. within the reinforced walls of the concrete stall at the Baton Rouge, La., refinery of Esso Standard Oil Company, above, are producing the first commercial quantities of a synthetic alcohol from gasoline, hydrogen and carbon monoxide in a new process developed by Esso Laboratories. Crude alcohol from the operation is cooled at the tank at left before being pumped to the finishing equipment.

The plant and process are currently being used to make iso-octyl alcohol for plasticizers, a basic ingredient in compounding and forming plastics and in giving flexibility and suppleness to the finished product. Esso is the first company to achieve commercial production of chemicals by this method, an adaptation of the Oxo process, which involves the reaction of a selected gasoline fraction with hydrogen and carbon monoxide gases in the presence of a special catalyst at a pressure of 3000 pounds per square inch. Crude alcohol is recovered from the high-pressure operation and purified to yield finished iso-octyl alcohol. The process is flexible and other alcohols and chemicals can be made from it.

E. H. Walker Appointed Vice President of Shell

E. H. Walker, general manager of Shell Oil Company's personnel and industrial relations organization, has been appointed a vice president. His new title coincides with a substantial increase in the activities of the personnel and industrial relations organization.

Walker

A graduate of Louisiana State University, Walker poined Shell in 1932 as a counterman in the storehouse at the Norco, La., refinery. Following service in a wide range of positions in the engineering department and in various operating departments at Norco, he was transferred to St. Louis in 1936 as personnel assistant in the manufacturing department. In 1940 he was named manager of the personnel department, with offices in New York, and three years later he became general manager of personnel and industrial relations.

Norman McGaw Elected To Shell's Board of Directors

Norman J. McGaw, vice president of Shell Oil Company, has been elected to the board of directors and has been assigned new duties with offices in New York. He will organize and direct a new department dealing with economic studies of the oil industry in general, as well as with Shell's own forward planning and major development projects.

McGaw

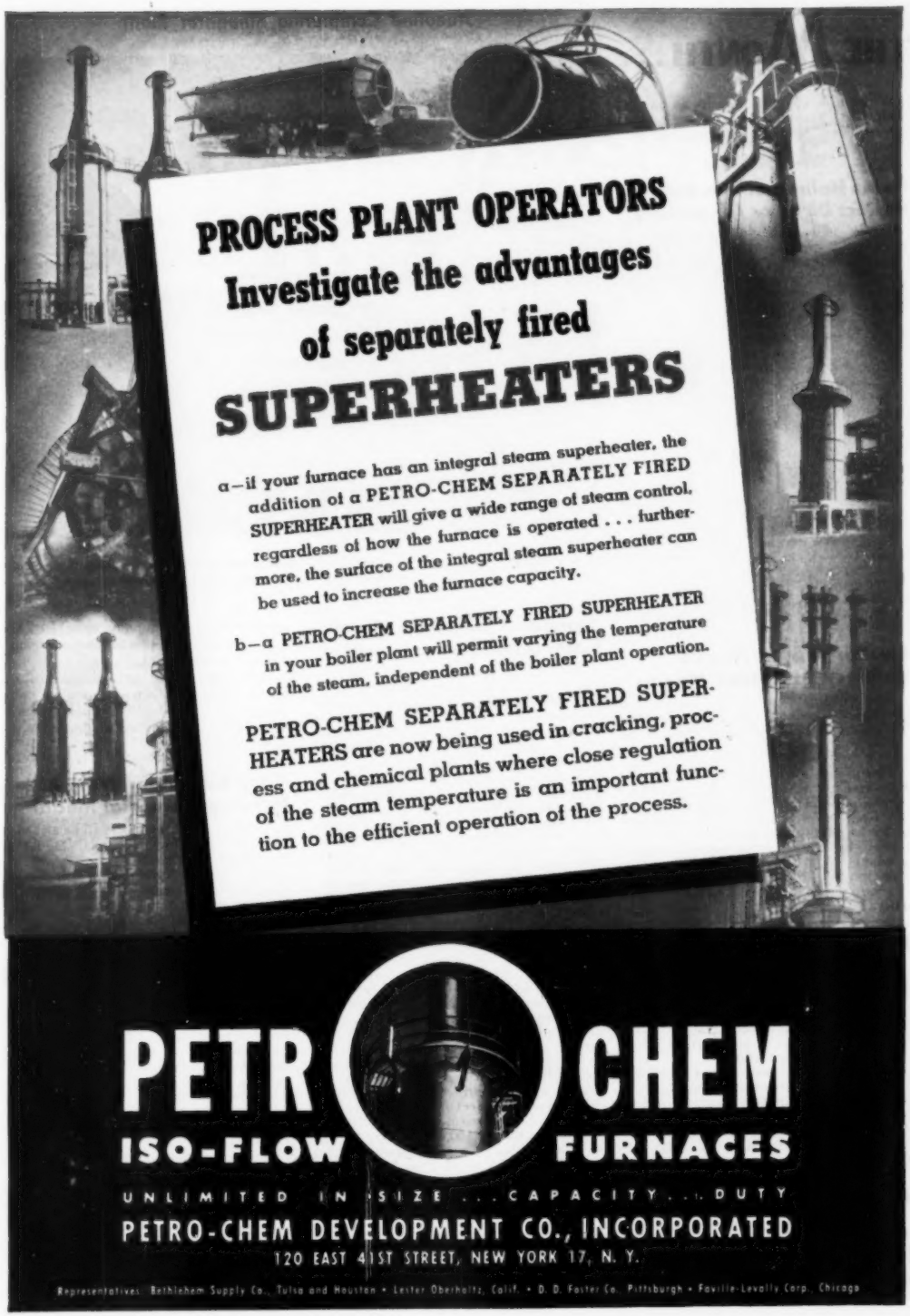
Joining Shell as a clerk in San Francisco in 1925, McGaw served in various capacities on the Pacific Coast before becoming assistant manager of manufacturing in 1932. The following year he was transferred to St. Louis, where he served first in the president's office and later as manager of transportation and supplies. McGaw was made vice president in charge of transportation and supplies in 1939. Since 1946, he has been general vice president in San Francisco.

David Liles Made Plant Foreman for Stanolind

David M. Liles, veteran of more than 20 years service, has been named plant foreman of Stanolind Oil and Gas Company's new natural gasoline plant at Stano, Kan.

Liles goes to Stano from Vivian, La., where he had been plant foreman at the Gilliam gasoline plant. Prior to that, he was an operator at the Jennings, La., recycling plant and the Superior refinery at Vivian.

Gilbert R. Wallace succeeds Liles as Gilliam plant foreman. He assumes his


PROCESS PLANT OPERATORS
Investigate the advantages
of separately fired
SUPERHEATERS
a—if your furnace has an integral steam superheater, the addition of a PETRO-CHEM SEPARATELY FIRED SUPERHEATER will give a wide range of steam control, regardless of how the furnace is operated . . . furthermore, the surface of the integral steam superheater can be used to increase the furnace capacity.
b—a PETRO-CHEM SEPARATELY FIRED SUPERHEATER in your boiler plant will permit varying the temperature of the steam, independent of the boiler plant operation.
PETRO-CHEM SEPARATELY FIRED SUPERHEATERS are now being used in cracking, process and chemical plants where close regulation of the steam temperature is an important function to the efficient operation of the process.
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ISO-FLOW FURNACES
UNLIMITED IN SIZE . . . CAPACITY . . . DUTY
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120 EAST 41ST STREET, NEW YORK 17, N. Y.
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THE MONTH...

new position after 19 months as an operator at Stanolind's Hastings plant, Alvin, Texas. He is also a 20-year veteran.

Heinz Heinemann to Become Project Director for Houdry

Heinz Heinemann, author of the monthly feature, "Digest of Recently Issued U. S. Patents Pertaining to Petroleum Refining, appearing in PETROLEUM REFINER, has become project director for Houdry Process Corporation.

Previous to this appointment he was research supervisor for Attapulgus Clay Company for seven years. In 1941 Heinemann served as assistant to the late Dr. Ernst Berl as research-fellow at the Carnegie Institute of Technology, organizing the research fellowship of the Dominican Republic. Before this he spent a year as research chemist for Danciger Oil and Refineries, Inc. Coming to the United States in 1938 after working for a year as assistant at the Frank's Laboratories, Berlin, Heinemann joined Rodessa Oil and Refining Corporation as chief research chemist.

Holder of a number of patents, Heinemann is a member of the American Chemical Society, New York Academy of Sciences, American Society for X-Ray and Electron Diffraction, Schweizerische Chem. Gesellschaft and A. A. A. S.

Sinclair Closes Fourth Refinery in Recent Months

Sinclair Oil Company will close shortly its refinery at Sand Springs, Okla., the 7000-barrel-daily plant being the fourth the company has closed in recent months.

Plants at Fort Worth, Texas and Kansas City, Kan., have already ceased operations and one at Coffeyville, Kan., has been ordered closed. The company plans to supply customers in the areas served by the four refineries from a products pipe line being built from Houston to Chicago. Total capacity of the four plants is 38,500 barrels of crude daily.

Fluor-Lewis Dissolved

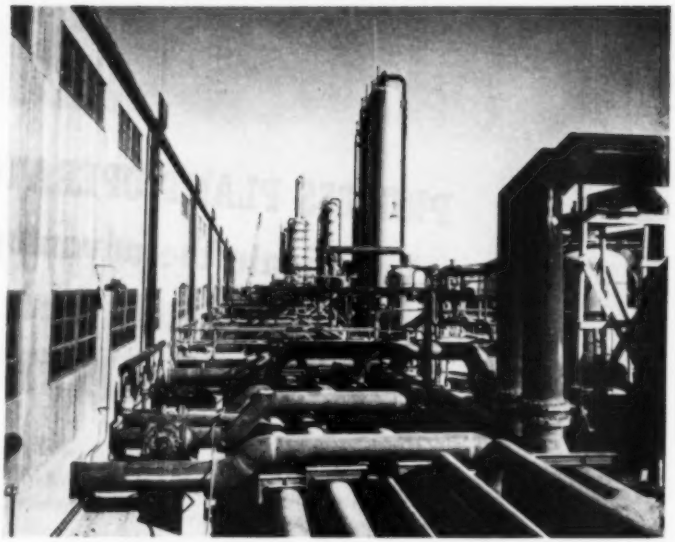
J. S. Fluor, Jr., has dissolved Fluor-Lewis Company, effective immediately. In announcing the dissolution he gave no immediate plans. However, it is known that he has large agricultural interests and that he retains a stock interest in Fluor Corporation.

Long connected with Fluor Corporation, he severed his connections with the organization some two years ago and formed his latest company to represent E. B. Badger and Sons. The Fluor-Lewis operations covered the entire Pacific Coast.

Robert D. Tucker Dies

Robert D. Tucker, retired employe of Socony-Vacuum Oil Company, Inc., died December 2 while on a vacation trip in Canada. Captain Tucker formerly was port captain at the Providence refinery of the company.

Stanolind Completing Slaughter Plant



View of Slaughter Field (near Levelland, Texas, gasoline plant being built by group of companies for which Stanolind Oil and Gas Company will be the operator.

Stanolind Slaughter Plant Completion Due in February

Beating construction schedules by nearly a month, the new Slaughter natural gasoline plant will begin operations in February. The plant is currently more than 80 per cent complete. Final completion of all facilities is scheduled for March.

Located some 13 miles southwest of Levelland, in Hockley County, Texas, it is one of four to be completed by Stanolind early in 1949. The others are the Stano gasoline plant, Ulysses, Kan., which will begin operations in February; Elk Basin gasoline plant, Powell, Wyo., also to start in February, and Burnell-North Pettus cycling plant, Pettus, Texas, which will be opened in May.

To be operated by Stanolind, the Slaughter plant is owned by eight companies. These are Stanolind, The Texas Company, Honolulu Oil Corporation, Magnolia Petroleum Company, Devonian Oil Company, the Atlantic Refining Company, Mid-Continent Petroleum Corporation and Saltmount Oil Company.

Designed for an ultimate capacity of 120 million cubic feet of gas daily, the Slaughter plant will operate initially at 90 million cubic feet per day. Daily output will be approximately 100,000 gallons of gasoline, 100,000 gallons of butane and 50 gallons of propane. Residue gas will be sold to El Paso Natural Gas Company.

C. F. Braun and Company is contractor.

Monsanto Promotes Two

Edward J. Bock has been named manager of the Monsanto, Tenn., plant of Monsanto Chemical Company. Associated with the company since 1941, he was formerly superintendent of maintenance at the plant.

Succeeding Bock as maintenance superintendent is Olin R. Bailey, who joined Monsanto in 1946. Bock was formerly chief construction engineer for the phosphate division.

Adolphus Pilger Wins ASE Horning Memorial Medal

Adolphus C. Pilger, Jr., will be awarded the 1947 Horning Memorial Medal at the annual meeting of the Society of Automotive Engineers January 10-14 at the Hotel Book-Cadillac in Detroit, for his adaptation of fuels to engines and engines to fuel. His new technique evaluates lubricating oil, gasoline and engine design factors in terms of deposits of engine varnish and sludge bearing corrosion. The new method produces highly accurate information because it can be set up as a permanent program.

Pilger

Graduating from Rutgers University in 1934 with a bachelor of science degree in mechanical engineering, Pilger joined Tide Water Associated Oil Company in 1936 as a research engineer in the Bayonne, N. J., automotive laboratory. The next year he transferred to the research and development department in Detroit and was placed in charge of automotive field research. In addition to handling technical liaison

A New Role for the HORTONSPHERE

—this time it's a DESALTER

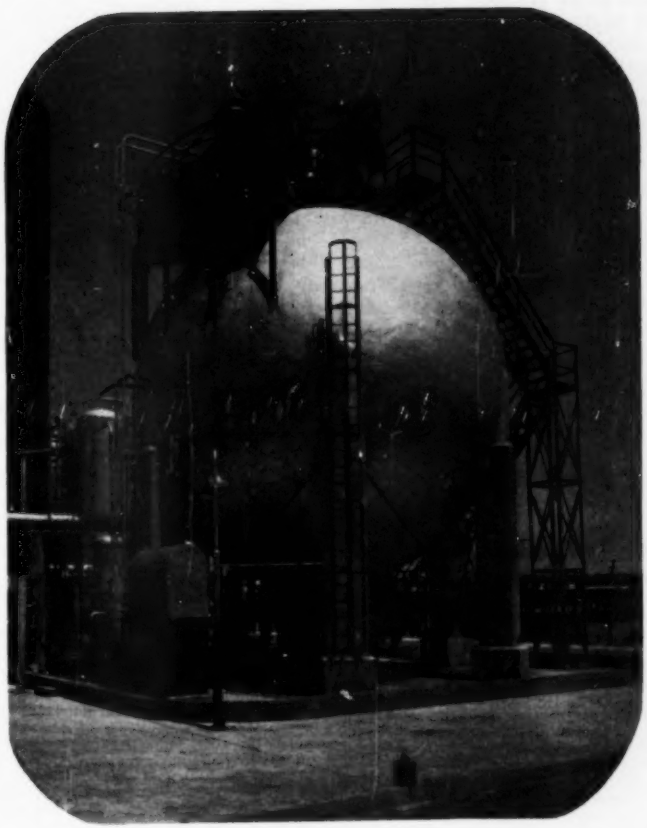
The versatile Hortonsphere has been adapted to a new job in the petroleum field—as an electric desalter for crude oil.

The Hortonsphere is well known as a pressure storage tank for highly volatile petroleum products, such as the more volatile grades of natural gasoline, butane and butane-propane mixtures. It is commonly used, in capacities from 1,000 to 25,000 bbls., to store liquids under pressure of 25 to 100 lbs. per sq. in., and has been built in smaller sizes to store propane at pressures up to 250 lbs. per sq. in.

Crude oil with a high salt content causes a serious reduction in efficiency and output of refinery units and necessitates frequent shut-downs. When used as a desalter, the Hortonsphere is equipped with an electrical unit developed by the Petroleum Rectifying Company. It removes salt from crude oil before the crude is charged into a refining unit.

In the desalting process, the salt-bearing crude charging stock passes through heat exchangers, is mixed with hot, fresh water and passed through an air-operated emulsifier. The mixture, usually 95 per cent oil and 5 per cent water, flows into the Electrosphere where it enters a high-voltage electric field. The water and brine particles are electrically attracted and coalesced, and the coalesced masses settle by gravity to the bottom of the sphere to be drawn off.

The Electrosphere (Hortonsphere plus desalter) is just one special application of the Hortonsphere. When you need steel tanks for special jobs, write to our nearest office.



The Hortonsphere shown above, fitted with an electric desalting unit, was installed at the Gulf Oil Corporation's Port Arthur, Texas, refinery. It treats an average of 16,248 bbls. of crude per day. The salt content of the crude is about 38 lbs. per 1,000 bbls., 93.9 per cent of which the desalter removes.

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PENNSYLVANIA

Atlanta 3 ..... 2146 Healey Building	Detroit 26 ..... 1520 Lafayette Building	Philadelphia 3 ..... 1608—1700 Walnut St. Building
Birmingham 1 ..... 1548 North Fiftieth Street	Havana ..... 402 Abreu Building	Salt Lake City 1 1531 First Security Bank Building
Boston 10 ..... 1030—201 Devonshire Street	Houston 2 ..... 2126 National Standard Building	San Francisco 11 ..... 1231-22 Battery St. Building
Chicago 4 ..... 2463 McCormick Building	Los Angeles 14 ..... 1434 Wm. Fox Building	Seattle 1 ..... 1331 Stuart Building
Cleveland 15 ..... 2234 Guildhall Building	New York 6 ..... 3302—165 Broadway Building	Tulsa 3 ..... 1626 Hunt Building

REPRESENTATIVES AND LICENSEES

Ateliers et Chantiers de la Seine Maritime, Paris, France
Chicago Bridge & Iron Company, Limited, Apartado 1348, Caracas, Venezuela
Compania Tecnica Industrie Petroli, S.A.I., Rome, Italy
Constructions Metalliques de Provence, Arles-sur-Rhone, France
Horton Steel Works, Limited, Fort Erie, Ontario, Canada
Leopoldo Sol & Cia., Reconquista 558, Buenos Aires, Argentina
Motherwell Bridge & Engineering Company, Limited, Motherwell, Scotland
Whessoe, Limited, Darlington, England

THE MONTH...

with automotive manufacturers, he assisted in establishing the Automotive Field Research Group which is evaluating lubricants and fuels by field research methods.

Campbell Named Manager Of British American Plants

David L. Campbell has been appointed manager of all the refineries of The British American Oil Company, Ltd. He will have his offices in Toronto, Ontario.

Campbell

Born in Nokomis, Saskatchewan, Campbell attended school there and later graduated from the University of Saskatchewan, getting his bachelor of science degree in chemical engineering.

Joining British-American in 1934 as an instrument man, he has worked his way up through various positions to manager of the Calgary refinery, the position he held before his recent appointment.

He is a director of the Calgary Kiwanis Club and a member of the Renfrew Club and the American Petroleum Institute.

Warren and Chicago Buy Midland Gasoline Stock

Chicago Corporation and Warren Petroleum Corporation have purchased all the outstanding capital stock of Midland Gasoline Company not already owned by Warren. Acquisition by Chicago Corporation was through a wholly owned subsidiary. The company will be operated under Warren management, subject to a board of directors composed equally of Warren and Chicago Corporation representatives.

Midland owns and operates a natural gasoline plant in the Conroe oil field of Texas and currently is producing approximately 45,000 gallons daily of natural gasoline and liquefied petroleum gases.

Standard and Subsidiaries Merge Asphalt Business

Consolidation of the western asphalt business of Standard Oil Company of California and its subsidiaries became effective January 1, 1949. The expanded operations will be carried on by Stancal Asphalt and Bitumuls Company, formerly known as California Asphalt Corporation. The home office will be in San Francisco, Calif., with district offices in Oakland and Inglewood, Calif., Tucson, Ariz., and Portland, Ore.

Merged into Stancal will be the western marketing staffs of American Bitumuls Company, another subsidiary, and Standard's own asphalt division. In addition to the California Asphalt Corporation refinery in Portland, the new company will operate the asphalt emulsion plants of American Bitumuls in Oakland, Inglewood and Tucson.

C. W. Stewart, head of American Bitumuls, will be president of the new organization, and N. H. Angell, formerly manager of Standard's asphalt division, will be vice president in charge of sales.

"This move is being made in recognition of the growing importance of the asphalt business both industrially and for paving," T. S. Petersen, president of Standard, said. "Consolidation of the various types of asphalt products offered will enable the Stancal Asphalt and Bitumuls Company to present a complete line.

Stancal will cover the territory west of the Rocky Mountains, while American Bitumuls will continue to operate east of the Rockies as a subsidiary.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,257	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	9,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,867	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,666	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,290	224,994	16,501	82,472	6,136	60,406	8,580	56,777
October 25	5,295	5,165	224,308	16,529	82,033	6,638	62,699	8,666	57,419
November 29	5,257	5,209	224,540	16,667	86,319	6,382	61,988	8,405	56,747
December 27	5,285	5,343	222,770	17,013	91,269	7,042	50,324	9,098	51,896
1948:									
January 31	5,318	5,434	221,663	15,986	102,973	7,690	40,580	9,141	50,839
February 28	5,387	5,463	220,507	15,796	111,040	7,963	33,836	8,824	49,206
March 27	5,377	5,324	222,814	15,783	112,991	7,682	30,717	8,854	48,334
April 24	5,415	5,317	221,652	16,315	111,128	6,831	34,237	8,877	49,572
May 29	5,452	5,715	221,703	17,327	107,185	7,054	38,641	9,308	55,146
June 26	5,494	5,674	222,081	17,938	104,178	7,200	43,166	8,858	58,812
July 31	5,455	5,718	223,137	17,646	99,116	6,823	50,661	9,080	65,713
August 28	5,529	5,682	222,170	17,722	95,504	7,491	66,321	8,818	79,853
September 25	*5,343	4,789	*226,072	15,103	78,669	5,997	61,884	6,380	37,326
October 30	5,604	5,626	230,633	17,569	91,925	7,679	81,593	8,853	81,299
November 27	5,617	5,721	234,585	17,317	93,802	7,476	85,151	9,477	86,192
December 25	5,641	5,784	†239,435	18,178	100,286	7,776	79,271	9,121	86,181

* Total U.S. All other September 25 figures do not include California, due to strike.
† December 18.

Increased Demand Forecast

Forecasts of crude oil demand in 1949 were announced last month by the United States Bureau of Mines, the Interstate Oil Compact Commission, and the Independent Petroleum Association of America. The Bureau of Mines has predicted an increase in total demand of 5.8 percent; Interstate Compact Commission, 6 percent, and the Independent Petroleum Association of America, 8.1 percent.

According to the Bureau of Mines, more than 3 percent of the total new supply of all oils in 1948 went into increased stocks of crude oil and products. Under this condition, the Bureau did not anticipate further increases in stocks during 1949.

The Bureau's forecast is based primarily on an estimate of an increase of 6.4 percent in the domestic demand for all oils, involving an increase of 8 percent in motor fuel demand, a decrease of about 1 percent in the demand for residual fuel oil, and gains of 12 percent in the demand for distillate fuel oil, 10 percent in kerosine demand, and 6 percent in the demand for other oils.

The Compact Commission's economic advisory committee reported that there does not seem to be any necessity to continue to increase inventories of crude oil and products next year.: Inventories actually increased about 230,000 barrels per day, the committee said, which means that in 1948 new production and other new supplies were made available over and above the demand for current consumption, and now may be used to supply a large share of the increase anticipated for 1949.

IPAA estimated the domestic demand for crude oil at 6,370,000 barrels per day during 1949, an increase in total domestic demand over 1948 of 8.8 percent. The association estimated domestic consumption figures of 8.8 percent for gasoline, 11.1 percent for kerosine, 16.3 percent for light fuel oils, 2.1 percent for heavy fuel oils, and 10.6 percent for all other products. Total demand including exports was estimated at 6,705,000 barrels per day during 1949, which represents an increase of 8.1 percent over 1948.

Co-ops Increase Members But Suffer Earnings Drop

During 1947 Consumer Co-operative Petroleum Association increased to 1400 groups with 925,000 members and handled business amounting to $320 million. This was a 9.6 percent increase in membership, but earnings averaged 7.9 percent, a decrease of 2.1 percent from 1946. However, the 1947 figure compared favorably with the 4.1 percent earnings of general retail co-operatives.

In a report prepared by the Bureau of Labor Statistics, it also was shown that losses for the groups dropped to 2.5 percent of total business, compared with 5 percent in 1946. Showing an increase of 26.3 percent in the volume of business, the total sales of $252,880 were $114,135 below the total sales for the average general retail co-op. Patronage

Inhibit Bearing Corrosion *Effectively*

Use Du Pont "Ortholeum" 202

Reg. U. S. Patent Office

If you have a bearing corrosion problem with solvent extracted motor oils, "Ortholeum" 202 Lubricant Assistant may be the answer. A sulfurized terpene hydrocarbon in which sulfur activity is carefully controlled, "Ortholeum" 202 has proved its corrosion inhibiting effectiveness in solvent extracted mid-continent stocks. It also has good E. P. properties. These, along with its sulfur activity, suggest the possible use as an additive for gear oils and cutting oils as well.

Ample Quantities are now available. Samples are also available for experimentation. Write the nearest District Office for samples and also for Technical Bulletin on Du Pont "Ortholeum" 202.

TYPICAL PROPERTIES OF "ORTHOLEUM" 202

DESCRIPTION: A viscous, clear, amber-colored liquid with a terpenic odor.	
Specific Gravity, 60°/60°F.	1.14
Color, N.P.A.	4
Viscosity at 210°F., S.U.S.	110
Pour Point °F	+35
Flash Point, °F. (C.O.C.)	235
Fire Point, °F. (C.O.C.)	255
Ash	Trace
Miscibility in Oil at room temperature	in all proportions
Sulfur, %	35
SULFUR ACTIVITY, COPPER STRIP*	
3 HOURS AT 210° F.	
0.5%	Light to Medium Brown
5.0%	Black
1 HOUR AT 250° F.	
0.5%	Medium Brown
2.5%	Black
1 HOUR AT 300° F.	
0.5%	Dark Brown
2.5%	Black

*VV-L-791c, Method 530.31, except for variations in time and temperature as noted.

Gasoline Oxidation Inhibitors

Tetraethyl Lead Compounds

Lubricating Oil Additives

Fuel Oil Additives

Gasoline Dyes

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PETROLEUM CHEMICALS

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

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THE MONTH . . .

refunds in the petroleum groups were the highest in the consumer co-op field, averaging 5.5 percent. Store associations had only 3.5 percent and service groups 4.5 percent.

Irving N. Simmons Heads Houdry Patent Division

Irving N. Simmons has been appointed head of the patent division of Houdry Process Corporation.

Simmons

He has been associated with Houdry since the firm had its founding in 1931 and as patent chief will be responsible for the development and maintenance of the corporation's patents.

Simmons' early engineering work was in connection with the design and operation of Houdry pilot and semi-commercial units. In 1933 he began liaison work between the patent division and the technical staff of the company's laboratories. Joining the patent division in 1934, he has continued his participation in the development of the Houdry patent position.

During World War II, Simmons worked with Eugene J. Houdry in a technical and plant capacity while the latter was engaged in war emergency work. He holds a bachelor degree in chemical engineering from Tufts College.

Blaw-Knox Promotes Wright To Construction Manager

The Chemical Plants division of Blaw-Knox Company has promoted E. S. Wright to manager of construction. W. F. O'Neill will succeed Wright as general superintendent of construction.

Joining the organization in 1942, Wright has since been active in every phase of the division's construction activities. Prior to his connection with Blaw-Knox, Wright was engaged in general contracting in Philadelphia and in oil refining and chemical processing work.

O'Neill has been with the division since 1941, except for three years army service. Prior to joining Blaw-Knox, he was in the construction industry on the West Coast.

Co-Op Buys Plant, Will Enlarge Another Property

Cooperative Refinery Association has purchased the 2000-barrel refinery of The Carter Oil Company at Newcastle, Wyo. The association took over operation of the refinery on December 31, 1948. Included in the purchase was a tank farm and nearly 50 acres of land.

Output of refined fuels will go to meet the needs of local petroleum cooperatives in eastern Wyoming and western South Dakota. The purchase will increase the daily consumption of crude oil by the group to 35,000 barrels daily.

"The purchase at Newcastle is the second step we have taken recently to increase our production of refined fuels," Howard A. Cowden, president of the association, said. "We are going to modernize and activate the high-octane plant at Coffeyville, Kans., which we operated for the Federal Government during the war but which we now own. That will cost $900,000 or more. Besides, we have steadily improved the refinery at Coffeyville purchased from National Refining Company in 1940. We own there also a lubricating oil refinery. Besides the Coffeyville facilities we have a one-third interest in the 20,000-barrel plant at McPherson, Kans., and own outright refineries at both Phillipsburg, Kans., and Scottsbluff, Nebr.

V. E. Middlebrook Becomes Engineering Consultant

V. E. Middlebrook, manager of gas-gasoline operations in the Mid-Continent area for Shell Oil Company, has resigned to become an active engineering consultant, with offices in the Citizens National Bank Building, Tulsa.

Middlebrook

Since Middlebrook's graduation (M. E. 1928), from Texas A. & M. he has been associated with Coltexo Corporation, Phillips Petroleum Company, Texas Empire Pipe Line Company, and for the past 12 years with Shell. Except for a brief period with Texas Empire Pipe Line Company in the East Texas field, he has spent the past 20 years designing and building natural gasoline, propane and butane recovery plants.

Richard Bard has been appointed gas-gasoline manager of the Tulsa area of Shell, succeeding Middlebrook.

A graduate of Ohio State University, he has spent 18 years in various phases of the oil industry relating to refining, etc. He previously was with the regional gas-gasoline staff in the Houston area.

Hargrove

Waterman

Badger Adds Two Officers

George C. Hargrove and Ralph D. Waterman have been elected vice presidents of E. B. Badger and Sons Company, Boston, a subsidiary of Stone and Webster, Inc.

In charge of general administration and sales, Hargrove has been with the company for 18 years.

Waterman will be in charge of engineering and construction. He has been associated with Badger for nine years.

Fred Meyer Heads Bechtel Division of Engineering

Fred W. Meyer has been named chief engineer of the engineering division of Bechtel Corporation with headquarters in the Bechtel Engineering Building at 62 First Street, San Francisco.

Meyer

Joining Bechtel in 1942 after seven years of refinery design and process engineering with Standard Oil Company of California, Meyer has been active on the 100-octane plant at Richmond, Calif., the butadiene plant at El Segundo and the toluene plant at Phillips Petroleum Company at Borger, Texas.

Meyer went to Japan as a member of a government board of civilian experts, serving as head of the Oil Ministerial Group of the United States Strategic Bombing Survey.

He is a graduate of the University of California and has a master's degree from Massachusetts Institute of Technology.

Saudi Arabia Crude for Pacific Coast Scheduled

The first "trial run" of Saudi Arabian crude oil to the Pacific Coast will arrive aboard the tanker M.S. California Standard sometime in mid-January, according to T. S. Petersen, president of Standard Oil Company of California.

Discharge of the 130,000-barrell cargo will be at Standard's Richmond refinery. The vessel loaded at Ras Tanura December 10 and is proceeding via the Pacific route.

Petersen emphasized that the shipment was purely of an experimental nature and did not in any way indicate plans in the immediate future to make regular hauls to the West Coast.

Vitameter Fleet Operation Extends, Tests Favorable

Through use of an anti-knock injection system, fleet maintenance savings of almost $90 per year per vehicle have been reported in Thompson-Toledo Vitameter Corporation field tests. Figures used in the report before the Cleveland section of the Society of Automotive Engineers were supplied by Cleveland Yellow Cab Company.

The company plans to extend its vitameter fleet operation in the near future, according to Van Hartesveldt, vice president of Thompson-Toledo. Sale of the device to passenger car users is confined to Columbus, Ohio, on a test basis.

Standard (Ohio) Makes Many New Appointments

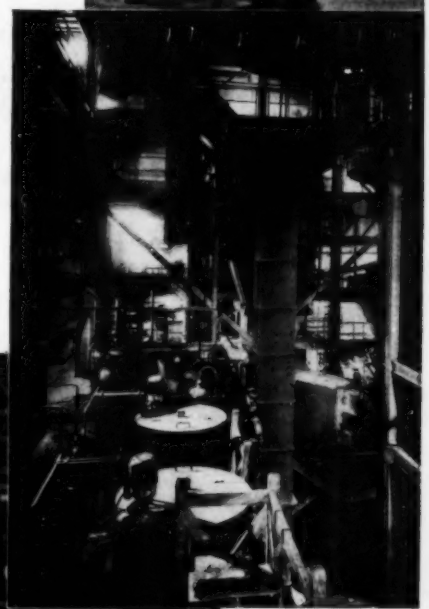
The Standard Oil Company (Ohio) has made many new appointments, effective January 1, 1949, as follows:

Richard S. Stewart to become assistant to the executive vice president.

Wallace K. Bergen to succeed Stewart as operations manager for the company's

. . . AS A SUPPLEMENTARY ORGANIZATION

To expedite the design and construction of a Pulp Mill for Marathon Paper Mills of Canada, Ltd., Stone & Webster Engineering Corporation established a supplementary organization of engineers, specialists and draftsmen to act as part of the client's own engineering department. The Engineering Corporation also furnished consulting advice on special phases of the project and supervised all the construction.



The Bleached Sulphate Pulp Mill of Marathon Paper Mills of Canada, Ltd., located at Marathon, Ontario, on the North Shore of Lake Superior.

Above: Power and Recovery Boiler Room. Left: Machine Room — Dry End.

STONE & WEBSTER ENGINEERING CORPORATION

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THE MONTH . . .

manufacturing department refineries and plants.

Ivan L. Peterson to succeed Bergen as manager of the refinery at Toledo, Ohio.

Seward R. Bolles to succeed Peterson as manager, Lima, Ohio, refinery.

Edward S. Bale to succeed Bolles as manager of the refinery at Latonia, Ky.

James S. Dalton to succeed Bale as general superintendent at the Cleveland No. 1 refinery.

Ray Elo to succeed Dalton as plant superintendent at Latonia.

Joseph August will become technical superintendent of the refinery at Lima.

Donald G. Stevens to succeed August as chief of the technical service division in Cleveland.

Edward N. Salathe to succeed Stevens as supervisor of the design and construction section of the general engineering division at Cleveland.

Norman C. Fuller to succeed Salathe as chief engineer of the Cleveland No. 1.

A. B. Van Buskirk Becomes Koppers Company Director

Arthur B. Van Buskirk has been elected a member of the board of directors of Koppers Company, Inc., Pittsburgh. He succeeds Donald D. Shepard, resigned. Buskirk is also vice president and a member of the board of governors of T. Mellon and Sons.

After graduation from Yale University and the law school of the University of Pennsylvania, he was associated with the law firm of Reed, Smith, Shaw and McClay. He resigned after Pearl Harbor to become deputy administrator of the Lend-Lease administration. Since the close of the war he has been associated with the Mellon family.

Atwater Joins Houston Staff of Thomas Bryan

A. C. Atwater has joined the staff of Thomas Bryan & Associates as manager of the petroleum and chemical division.

Atwater

A graduate of Massachusetts Institute of Technology with an S.B. and M.S. degree in chemical engineering, classes of 1920 and 1921, Atwater has been associated with many large companies. These include The Atlantic Refining Company, where he was development engineer on cracking and later assistant superintendent of their Pittsburgh refinery.

In 1928, Atwater went with Arthur G. McKee & Company, of Cleveland, as process design engineer on complete refinery construction. He served this company not only in the U. S. but also in Japan and Europe. He opened and operated McKee's New York sales office for about a year before joining the Alco Products Division of American Locomotive Company which he served until November, 1939, when the company's war orders necessitated discontinuance of their refinery engineering and contracting operations.

In 1940, Atwater rejoined McKee and soon afterward was named project purchasing manager for a complete $75 million steel plant for Brazil, and following that for a $30 million steel plant for Inland Steel Company.

Coming to Houston for McKee in 1943, he was project manager on many large construction jobs in this area as well as supervising McKee's Houston office staff field forces. He recently returned from Rotterdam where he was project and purchasing manager for the construction of the California Texas Oil Co., Ltd., refining plant.

$24 Million Research Plan

Research work, requiring an expenditure of $24 million, will be undertaken by Royal Dutch-Shell group in 1949. The program will include fundamental research, extending from the initial search for crude to the use of all kinds of petroleum fuels, lubricants and other products. Special attention will be given to farm use of petroleum products, particularly in the tropical areas.

E. Q. Beckwith Named LPG Manager for Sid Richardson

E. Q. Beckwith has been named manager of liquefied gas sales for Sid Richardson Gasoline Company with headquarters in Fort Worth.

Beckwith

Previously he was associated with Phillips Petroleum Company where he was active in LPG sales, engineering and product procurement work. Beckwith resigned as president of Beacon Petroleum Company, Tulsa, in September.

During the war he was in the ordnance department at Washington, also served as commanding officer at the Lima (Ohio) Tank Depot.

The Richardson company will complete its natural gasoline plant near Kermit, Texas, in February, 1949. It will have a daily production of 100,000 gallons of propane and butane and 100,000 gallons of natural gasoline.

Synthetic Fuels—Views and News

Continuous Type Retort Successful in First Run

Going beyond the Fischer Assay value of 30 gallons per ton of shale used, the initial run of the new continuous-type retort at the Rifle, Colo., oil shale demonstration plant of the Bureau of Mines "exceeded expectations." Spent shale processed in the test yielded no additional oil on assay, indicating that extraction in the retort was complete.

Due to "minor mechanical difficulties" no performance data are available. According to officials, the body of the retort worked fine but there were some "bugs" in the burning end of the retort and in the shale discharge unit. Difficulties encountered were similar to those experienced by Standard Oil Development Company in its work at Baton Rouge, La.

Synthetic Fuel Industry Not Necessary at Present

Large reserves of crude oil and the higher price of synthetic production make the creation of a synthetic fuel industry to satisy world oil requirements not immediately necessary, Dr. E. V. Murphree, president of Standard Oil Development Company, told members of the New York section of the American Chemical Society last month.

Recent crude reserve surveys "have indicated that the potential yield of crude petroleum of both the United States and the world is quite high, for the world as a whole amounting to some 264 years of supply at the present rate of consumption," he estimated.

Production of gasoline from natural gas is costly because of the high equipment investment necessary. Gasoline from coal or oil shale will cost from three to six cents more per gallon, Dr. Murphree declared.

In concluding he discussed the current trends in synthetic fuel production. He predicted that "in the future it may well turn out that it will be possible to produce gasoline from either oil shale or coal at a price that will compare favorably with the cost of production from crude oil."

New Techniques to Reduce Cost of Synthetic Fuels

With the development of new techniques for hydrogenating coal in the synthesis of gasoline and oil, Dr. Henry H. Storch, chief of research and development of the Bureau of Mines office of liquid synthetic fuels, Bruceton, Pa., laboratory, predicted a "significant reduction in the cost" of producing synthetic fuels. At the present time hydrogen cost is 50 percent of the total expenditure.

Speaking before the Pittsburgh section of the American Chemical Society, Dr. Storch explained that hydrogen is used at lower pressures in producing synthetic fuels by coal hydrogenation. It can be obtained from hydrogen mixtures used directly in the process and cheaper than pure hydrogen. Using different hydrogen types helps to save on investments in and maintenance of equipment, he concluded.

Industry Must Note Other Sources of Oil, Gasoline

The oil industry must devote increasing attention to possible alternative sources of gasoline and oil, Dr. Robert E. Wilson, chairman of the board for Standard Oil Company (Indiana), told members of the New York Academy of Sciences at the organization's annual meeting last month, for it cannot become

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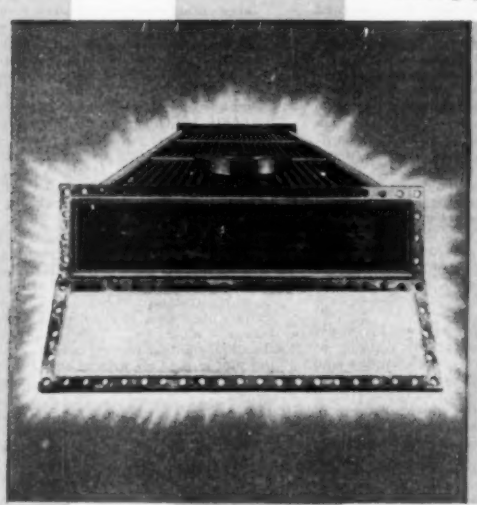

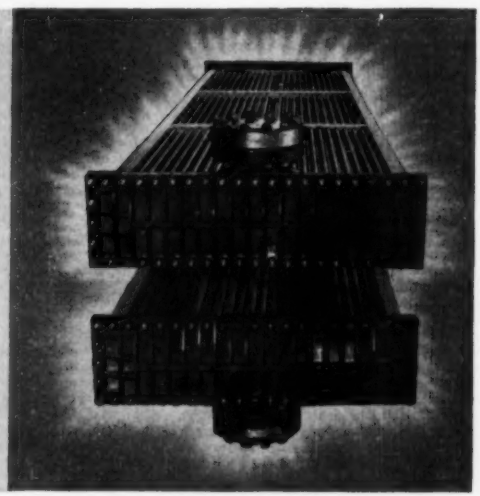

Typical of a large group of sections supplied to a Gulf Coast petro-chemical plant are these high pressure stainless steel sections. Headers are removable cover plate type of cast stainless steel with tongue and groove type confined gasket construction. Tubes are stainless steel.

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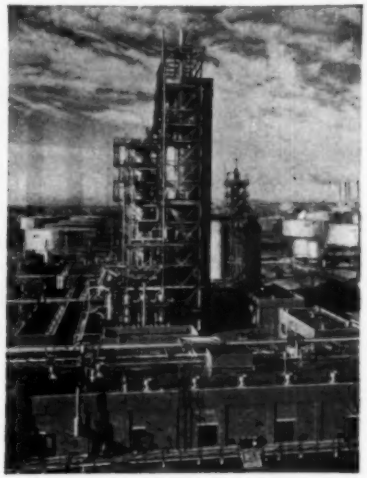
NUMBER 7 IN A SERIES

The important question in foreign refinery construction is "Which Master Contractor?"



GREAT pressure for refinery expansion and refinery modernization is now being felt in foreign fields, where both a ten year hiatus in building and major war destruction must be overcome. The new capacity required is large and presents serious capital outlay problems to both foreign national refiners and foreign subsidiaries of American companies.

The *master* contract type of operation, concentrating all engineering, material procurement and construction responsibility at any one refinery site in one organization's hands, is especially desirable in this work because of the inherent potential for major capital savings which has been established previously in this series.

Thus, the question facing refiners undertaking projects for installation outside the United States becomes not *whether* to use the *master* contract type of operation but, rather, *which* "master" contractor to engage. To clarify consideration of this latter question, Kellogg presents what it believes to be the most important factors which should be taken into account when selecting a *master* contractor for foreign work.

First, it would appear most important to select an engineer-contractor that has had repeated experience with the multitudinous responsibilities of varied types of *master* contract operations and naturally a successful record.

Further, the contractor's *existing* establishment, in manpower and resources, should be capable of handling the entire project both expeditiously and efficiently *within his own organization.*

Second, this contractor should have had experience in *foreign* operations—not necessarily at the particular location of the proposed job, but most assuredly at a sufficient number of foreign locations so that the contractor's organization shall have learned *previously* the many unusual, and in many respects more difficult, requirements of foreign operation.

Third, the contractor's design groups—laboratory, process and mechanical—should have *a secure and unquestioned engineering reputation,* eliminating any desire or need to build "monuments to advanced processing" for prestige purposes, when such refinements are not justified by immediate and specific economic need. In short, the contractor's engineers should be mentally conditioned to approach the planning of each project on one basis only—*to design facilities which will meet the immediate and foreseeable market demands and in so doing earn the most pesos, cruzeiros, dinars, pounds, or francs over a period of years for the least immediate capital outlay.*

Fourth, under present world supply conditions, the contractor's ability to perform effectively the complex and difficult *task of procurement* of materials and equipment will prove critical in accelerating the on-stream date of the plant. Maximum speed and final economy in the conduct of this responsibility requires three basic capabilities: An existing procurement group *large* enough and *experienced* enough to purchase, inspect and expedite with thoroughness and dispatch the thousands of items of material and equipment which comprise a major refinery project; an *up-to-the-minute detailed knowledge of world-wide sources of supply,* which can be maintained only through active purchasing activity carried on constantly over the years in the major markets of the world; together with the "know-how" to utilize local currencies to the utmost in the procurement phase.

Fifth, the contractor must be capable of putting into the field when construction begins, *a quality of field supervisory and technical personnel equal to the magnitude of the task* . . . men accustomed to handling large-scale field administrative problems equivalent to those of a small city . . . men equipped by education, training and experience to solve problems in the field without need for reference to home office rulings and engineering advice.

Experience is the basis for this evaluation of the major considerations to be resolved by any refiner undertaking refinery construction outside the United States. *Experience* that has paralleled the growth of the refining industry, extended over a period of some thirty years, and embraced refinery projects of all kinds in practically every corner of the globe. It is *experience* that is further substantiated by foreign contracts currently entrusted to Kellogg totalling more than a hundred million dollars embracing *21 separate projects in Argentina, Belgium, Brazil, Canada, France, the Middle East, the United Kingdom and Venezuela.*

BENNETT ARCHAMBAULT
Treasurer
In Charge of Foreign Contracts
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Our company—M. W. Kellogg—is completely staffed and equipped for refinery and chemical plant design and construction, from the step of laboratory research through the initial operation of completed plants. It periodically issues a publication called the KELLOGGRAM, which describes many of these services. If you are not already receiving it, we will be glad to add your name to the list if you will drop us a line at 225 Broadway, New York 7, N. Y.

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complacent about oil reserves in the face of ever increasing demand.

In an effort to meet the current demand, gasoline now is being made from natural gas by the snthol process, Dr. Wilson pointed out, declaring the price is even comparable and large reserves of natural gas are available. Gasoline can also be made from coal and lignite at a cost little above the present costs of crude, he added.

Expenditures totaling $3 billion per year will make it possible for the oil industry to supply a demand half again as great as prewar and one-sixth greater than war-time peak. "We cannot remain complacent," he said, because demand in 1970 is expected to reach 2 billion barrels. Although gasoline from coal is in the future, the possibility does avoid the danger of running out of oil and tends to set a ceiling on petroleum prices, Dr. Wilson commented.

Says Develop Synthetic Fuels Now for Future

Although oil company executives agree that coal, oil shale and natural gas will become a major source of oil supply in the future, W. C. Schroeder, chief of the Bureau of Mines office of synthetic liquid fuels, urged in a talk last month before the 69th annual meeting of the American Society of Mechanical Engineers that the development of synthetic fuel plants should be immediate.

He warned that "traditional wildcatting and geophysical exploration" can no longer assure that future demands, essential for economic welfare and military security of the United States will be met. Predicting civilian increase in demand up to two million barrels daily, he said that it would be unwise to depend on foreign oil sources.

Reasoning that a synthetics industry cannot be established overnight, Schroeder said that several developments should be started at once. The Wolverton bill, up for hearings in the next congressional session, would take "our objective of self sufficiency in oil, no matter what the future holds, a long step forward. Several operating synthetic fuel plants, envisaged by the bill, would provide the essential link between pilot plant research and commercial production," he explained.

E. G. Dahlgren Resigns

E. G. Dahlgren has resigned as assistant secretary of Interstate Oil Compact Commission to become a consulting geologist in Oklahoma City, Okla.

A 1929 graduate of the University of Wisconsin, Dahlgren served with the oil and gas conservation departments in Oklahoma and Kansas, before joining the Compact staff.

N. H. Angell Heads Group

Normal H. Angell, Standard Oil Company of California, has been elected president and executive committee chairman of the Asphalt Institute for 1949. He succeeds A. M. Maxwell, who will continue as a member of the executive committee.

See Diesel Oil Activities First Hand

Under the sponsorship of the Diesel Engine Manufacturing Association, a group of mechanical engineering professors, pictured above, met recently in an all-day session at Shell Oil Company's Wood River, Ill., research laboratories. The meeting is one of a series being conducted by the association to permit mechanical engineering instructors to see first hand the processes by which diesel oils are produced and to enable them to hear lectures by oil men on the latest manufacturing processes and research aims.

A round-table discussion of test techniques provided an opportunity for an exchange of information on new methods of testing and new developments in instrumentation. How research problems originating either in the field or in the laboratory help industry engineers to anticipate future requirements was also discussed. During the session the group inspected the engine and chemical sections of the laboratories and the asphalt and gas turbine laboratories. The meeting closed with a discussion of how universities can best prepare men to meet the demands of industrial research and how industry can help the colleges with this problem.

Oil Companies Sponsor Seven Army Reserve Units

Oil companies are sponsoring seven more affiliated units in the Army's organized reserve corps. Under the program, members of each unit meet twice a month for specialized training that will enable them to move into the field as a unit in the event of war.

Sun Oil Company in activation of its 701st Engineers Petroleum distribution company and 942nd Quartermaster Petroleum Products laboratory brings the total of units in training at the company's Marcus Hook, Pa., refinery to three. Four more will be added shortly.

Tide Water Associated Oil Company has formed an Engineer Petroleum distribution company at New York and Gulf Oil Corporation has organized a Chemical Smoke Generator company at Philadelphia. At Denver, Colo., Bay Petroleum Company has organized a Quartermaster Petroleum Products laboratory base. Sponsoring a Quartermaster Gasoline supply company at Louisville, Ky., is Aetna Oil Company. Frontier Refining Company has formed a Quartermaster Base Petroleum supply company at Cheyenne, Wyo.

Robert Matteson Chairman Of Engineering Council

Robert Matteson has been named chairman of the San Francisco Engineering Council, an organization made up of eleven major engineering and technical societies. He will hold office through 1949.

Matteson is head of the analytical laboratory at the Richmond Laboratories of California Research Corporation, a subsidiary of Standard Oil Company of California. A member of the American Chemical Society, he is past chairman of that organization's California section.

Motion Films for Employe Training Now Catalogued

Results of the most comprehensive survey to date of motion pictures and slide films suitable for employe training in petroleum and allied fields are available in catalog form from the American Petroleum Institute, 50 West 50th Street, New York 20, for $3 per copy.

The study, made by Film Counselors for the API, includes an analysis of available films and resulted in the preparation of a film manual and catalog for all personnel and training directors.

More than 1300 motion pictures and slide films are reviewed and source and availability indicated. A source index and geographical list of film libraries are included as well as suggestions for the efficient use of films in training program.

Jefferson To Consolidate Research Group at Austin

Jefferson Chemical Company, Inc.'s consolidated research facilities in Austin, Texas, will combine research, process development and pilot plant activities now being carried on in New York City and Port Arthur, Texas.

A major factor in favor of Austin was the library and educational facilities offered by the University of Texas. The property chosen covers 69 acres and includes 5 buildings on 7 acres of improved

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land just inside the northern city limits of Austin. Plans call for remodeling the present buildings to make them suitable for chemical research activities. When this work has been completed, the initial staff will consist of about 65 people. Further construction work will be done as the company expands its research activities.

California Standard Plans Refinery, Ocean Terminal

Standard Oil Company of California is planning to construct a refinery and ocean tanker terminal in Venezuela. Scheduled for completion in 1950, the refinery will be located near Lake Maracaibo. Crude for the unit will be supplied from the Boscan field of Richmond Exploration Company, a Standard subsidiary.

Frequent Oil Changes For Autos Frowned Upon

The Bureau of Federal Supply has recommended that all federal agencies have the crankcase oil in their automobiles, trucks and busses changed only in the spring and fall or every 4000 miles, as a result of conclusions reached by the technical committee on lubricants and the liquid fuels of the federal specification board. The committee holds that more frequent oil changes are unnecessary under normal driving conditions and controlled preventive maintenance.

Efficient oil filters should be used and engines kept on schedule of corrective and preventive maintenance, the committee cautioned. Shorter intervals between changes are desirable in stop-and-go service in cold weather and where sand and dust are often encountered, it was suggested.

Standard Elects Gage Lund

Gage Lund has been elected a vice president of Standard Oil Company of California. A director of Standard since January, 1948, he also is chairman of the board of The California Company, Standard Oil Company of Texas, both wholly-owned subsidiaries operating in the Rocky Mountains, and Richmond Exploration Company, Standard's subsidiary in Venezuela. He joined Standard as a geologist in 1925, a year after his graduation from Stanford University.

Frank Williams Is Chairman

Frank S. G. Williams has been named chairman of the sectional committee B-31 of the American Society of Mechanical Engineers, which is responsible for the American Standard Code for Pressure Piping. Williams is eastern manager of Taylor Forge and Pipe Works.

W. C. MacMillan Promoted

W. C. MacMillan has been elevated to the newly created position of vice president and administrative assistant to L. F. McCollum, president of Continental Oil Company, effective January 1, 1949. Since 1943 he has been vice president in charge of production.

Present Profits Make Possible Expanded Supply and Facilities of Oil Industry

Oil industry earnings, under investigation by a joint Congressional Economic Subcommittee, have been given credit for converting "the petroleum situation from one of scarcity into one of abundance" by Joseph E. Pogue, vice president of Chase National Bank and a witness before the committee. The oil shortage would have been prolonged, Pogue declared, if capital expenditures by the companies for replacement and expansion of equipment and facilities had been less.

"In view of these circumstances, it can scarcely be claimed that the earnings of the oil industry were too great. The earnings played an essential role in the process of capital formation. Nor was too much capital formed in 1947," he continued. "It can be stated with assurance that it was the magnitude of capital formation in 1947 and in 1948 which has converted the petroleum situation from one of scarcity into one of abundance."

However, Pogue predicted that prices and profits in oil industry will drop as soon as large plant replacement and expansion expenditures are no longer necessary. "Already the prices of certain oil products in certain parts of the country have shown some measure of weakness and decline," Pogue observed, and "if prices are lower, profits will decrease."

Pogue claimed that the present "price structure" of the industry is adequate to maintain the industry. "The job has been compounding," he explained. "It has been a replacement job, an expansion job and it has been a make-up-for-lost-time. It is reasonable to expect that the job ahead, baring renewed inflation, would not have the same magnitude."

Depreciation's Dollar

Answering the question about the overstatement of profits, Pogue declared that profits were overstated, because net income included depreciation figured on the basis of current dollars which in turn have less value than pre-war dollars which purchased most of the depreciated equipment.

In 1947 a group of 30 representative companies "generated cash out of its own operations to the extent of $2160 million. The sum was segregated into $1219 million of net income and $941 million of depreciation, depletion and similar expenses." However, Pogue continued, "the latter sum, representing the capital or physical facilities worn out and used up during the year, was inadequate because costs had gone up. Outside funds, amounting to $743 million, were also obtained through long-term debt issuance, sales of common and preferred stock and the sale of assets. Over 71 percent of the two total amounts obtained went into capital expenditures," he declared.

Figures for expenditures, with one exception, are expressed in the current value of a dollar, Pogue pointed out. "The item of capital extinguishments is estimated on the basis of past dollars and therefore part of the net income dollars must be allocated to this item when it becomes converted into physical replacement of capital worn out and used up." Reported net income of the group of companies in 1946 was $736 million and $1219 million in 1947. After adjusting profits to reflect current-dollar cost of replacements, he said, net income would be $418 million for 1946 and $513 million for 1947.

Income for the first three quarters of 1948 for the oil group was $1410 million but, Pogue emphasized, capital expenditures will be greater also by $600 to $700 million, thus "drawing off most of the increment and converting these funds into physical plant, equipment and inventories. Thus it appears that in 1948 only 24 percent of reported net income will be paid out in the form of cash dividends. This drop in rate of disbursements is pretty conclusive proof that the industry was strapped for cash in 1948 despite the magnitude of its income and that earnings were further converted into fixed assets," Pogue concluded.

The present level of profits in the petroleum industry was also defended by Robert G. Dunlop, president of Sun Oil Company, and Eugene Holman, president of Standard Oil Company (New Jersey).

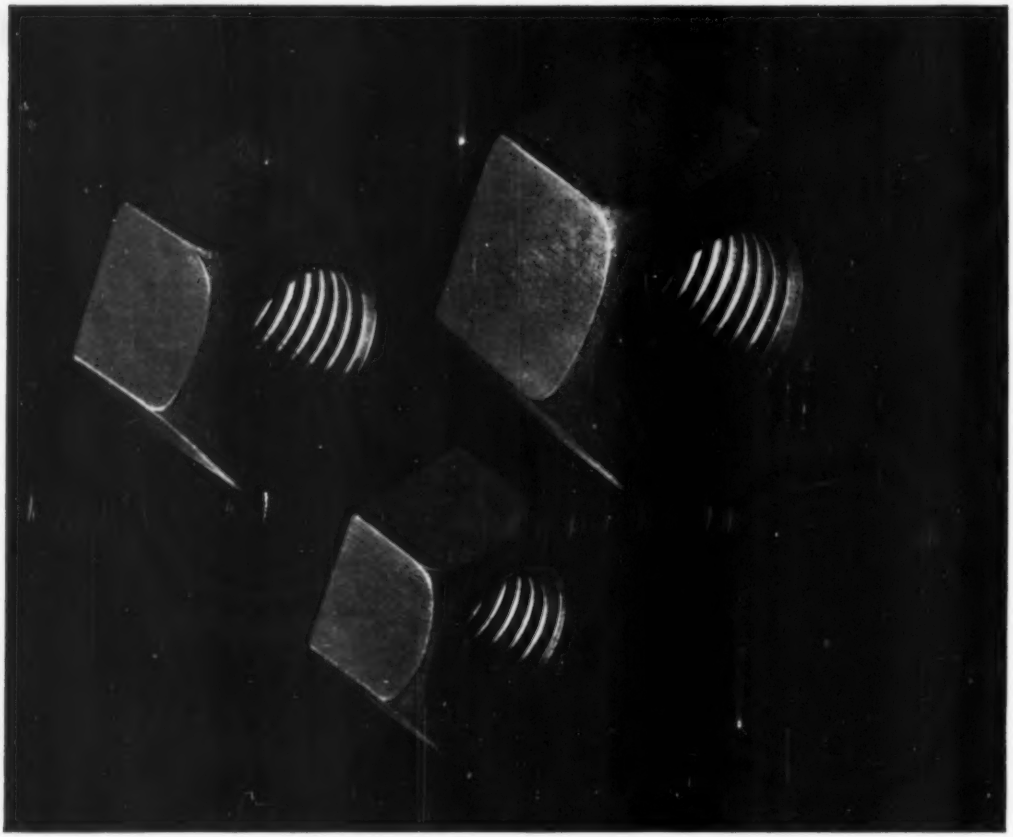
"Increased prices have had the effect of increasing supplies of oil and this is what the consuming public has desired. While increased "dollar profits" have resulted from these prices, the higher profits have made possible tremendous expansion programs to meet consumer demands," Dunlop pointed out.

Holman reported that "during the post war years, every dollar of Standard's profit over and above conservative dividends to stockholders has gone into new equipment and facilities to meet consumers' needs for oil. If the oil industry had not made the very great expenditures for new facilities which they have, there would be rationing of oil in this country right now. Thus an important beneficiary of Standard's profits has been the public."

Both men agreed with Pogue that in the future there is a possibility of a lessening in expansion requirements. Dunlop declared that it is still a little early to be definite but, "we may be entering the final phase of economic cycle, with supply outrunning demand and reduction of oil prices and oil profits in prospect.

"Looking ahead," Holman stated, "I believe it is beginning to appear that the tremendous rate of expansion which has been required of the industry may lessen somewhat. We think that the demand for petroleum will continue to rise, but that the rate of increase which has marked the postwar years may taper off. If that proves correct, it follows that demand for new capital formation in the petroleum industry may level out."

In concluding the hearing Dunlop observed that "our postwar profits have been reasonably adequate to permit us to fulfill the responsibility resting upon us of maintaining and expanding our facilities to help meet the increased demands of the public and of the armed forces for petroleum products. In order to do this, however, it has been necessary for us to retain an increasing proportion of our net earnings."



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SCIENCE and TECHNOLOGY Abstracts

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CHEMICAL COMPOSITION AND REACTIONS

Chlorination of Methane with Copper Chloride Melts. EVERETT GORIN, C. M. FONTANA, AND G. A. KIDDER, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2128-34 and pp. 2135-8.

The first of two articles is concerned with the rate of chlorination of methane by ternary melt potassium chloride-cuprous chloride-cupric chloride. The difficulty with direct chlorination is that a large amount of hydrogen chloride is produced as a by-product and furthermore, the reactions of hydrocarbons with chlorine are considered to be exothermic and thus difficult to control. The process proposed by the authors avoids these troubles by chlorinating the hydrocarbons in the first phase by means of cupric chloride chlorinating agent. The subsequent phase is an oxidation with hydrogen chloride and air. The first section of the article is concerned with the rate and the mechanism of the reaction. The second portion of the article deals with the distribution of the chlorination products obtained in chlorinating methane with the melt in the temperature range 425 to 500° C. Reactors of both falling film and bubbler type were employed. A higher yield of methyl chloride was obtained in the bubbler type reactor. However, the yield so obtained was lower than that obtained by previous investigators using free chlorine as a chlorinating agent. Variations in temperature and cupric concentration as well as small amounts of oxygen and carbon monoxide had little effect on the distribution of the composition of the product. Chlorination of methane in a fluidized bed with an agent comprised of alumina gel impregnated with a potassium chloride-copper chloride melt gave approximately the same product distribution as was obtained from use of the bubbler reactor.

Substitution vs. Addition in the Low Temperature Non-activated Chlorination of Olefins, an Argument for an Ionic Substitution Mechanism. ROBERT W. TAFT, JR., *Jour. Am. Chem. Soc.* **70** (1948), pp. 3364-9.

The author reviews various possible mechanisms of low temperature non-activated chlorination of olefins, and concludes that an ionic type mechanism is the only likely one. The rate-determining step is the addition of a positive chlorine ion to form a carbonium ion and a negative chloride ion. The intermediate carbonium ion follows two distinct reaction courses rapidly and simultaneously, these resulting either in addition or substitution products.

Chemicals Wanted

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Pyrazine
Pentazine
1,2,4-Trimethyl-3, 5-dihydroxybenzene
8-Quinoline sulfonic acid
N-Methylformanilide
α-Benzoinoxime
β-Benzoinoxime
α-Benzilmonoxime
β-Benzilmonoxime
Diamylstrontium
N, N-Dimethylhydrazine dihydrochloride
2-Methyl-1,3-dichloropropane
3-Nitro-2-methyl-1-propanol
4-Nitro-1-butanol
4-Nitro-2-butanol
3-Nitro-1-butanol
N-tert.-Butylhydroxylamine
2-Methyl-2-nitrosopropane
2-Methyl-1-nitropropane
2-Methyl-2-nitropropane
Triallyl amine
1,1,4,4-Tetraethoxybutene-2
2,4,6-Tribromobenzyl bromide
Dilauryl sulfone

Depolymerization of Butylene Polymers. F. G. CIAPETTA, S. J. MACUGA, AND L. N. LEUM, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2091-9.

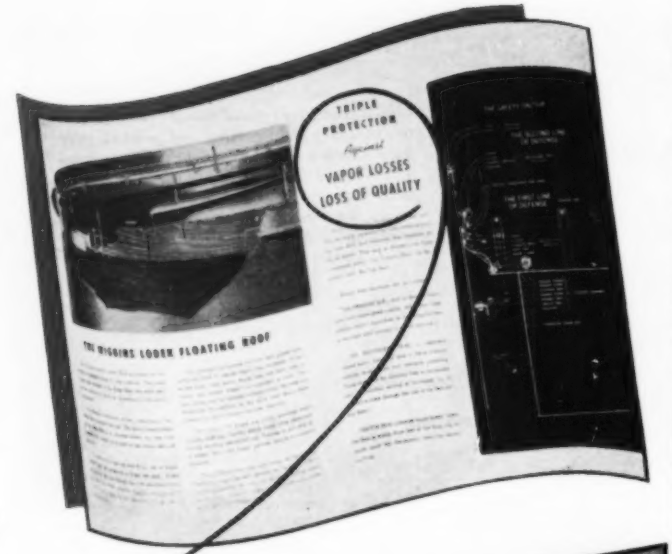
Catalytic depolymerizations of C_4 homopolymers of isobutylene and its copolymers with n-butylene were studied with the object of making pure isobutylene. Attapulgus clay was found to be a good catalyst for this reaction, as it produced a C_4 stream from homopolymers of better than 99 percent isobutylene. With various codimers as feeds, isobutylene concentrations of 90 to 98 percent were obtained. Mass spectrometer analyses of both gaseous and liquid products in two experiments showed that the carbon skeleton isomerization of the C_8 olefins accompanied depolymerization. Explanations of depolymerizations and isomerizations by the carbonium-ion mechanism are presented. Experimental procedures are described and the data presented in some detail in tabular and graphical form. A bibliography of 24 references is included.

1,3,5-Hexatriene. G. FORREST WOODS AND LOUIS H. SCHWARTZMAN, *Jour. Am. Chem. Soc.* **70** (1948), pp. 3394-6.

1,3,5-Hexatriene is of interest because it is the simplest conjugated triene, and its structure predicts two geometrical isomers, the cis-form being the open chain analog of benzene. 1,3-Hexadiene-5-ol was prepared by the reaction of pentadienal with methylmagnesium bromide and was dehydrated over alumina catalyst to 1,3,5-hexatriene, which compound was purified by low temperature crystallization. Boiling and freezing points, surface tension, heat of vaporization, dipole moment, refractive index, ultraviolet and infrared absorption spectra are reported.

Aluminum Chloride Solutions in Nitroparaffins, Catalysts for Hydrocarbon Reactions. LOUIS SCHMERLING, *Ind. Eng. Chem.* **40** (1948), pp. 2072-7.

Anhydrous aluminum chloride dissolves readily in nitromethane, nitroethane, and the two nitropropanes yielding solutions which, in contrast to those in alcohols, ethers, and ketones, are catalytically active. The active component is the addition complex, $AlCl_3RNO_2$. Nitroparaffin solutions of aluminum chloride are miscible with benzene; nitroparaffins are thus solubilizers for metal chloride in the hydrocarbon. Homogeneous phase alkylation can be accomplished by contacting the clear solution with olefin or alkyl halide. If it is desired to recycle the catalyst, the catalyst layer can be salted out by adding sodium chloride. Solutions of aluminum chloride in the nitroparaffins can also be used for the alkylation of isoparaffins with defins. The solutions are not soluble in paraffins and are available for recycling. Higher reaction temperatures are necessary than those used with unmodified aluminum chloride. Data are given and discussed for the alkylation of isobutane with propene. When isopropyl chloride is brought into contact with isobutane in the presence of unmodified aluminum chloride, the main reaction is reduction of the alkyl chloride to propane. On the other hand, if a solution of aluminum chloride in nitromethane is used as a catalyst, reduction of the isopropyl chlo-



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CANADA: Toronto Iron Works Ltd., Toronto

ride is greatly decreased and alkylation of isobutane to heptane occurs. Nitroparaffin solutions of aluminum chloride effect almost no isomerization of n-pentane or methylcyclopentane. A bibliography of ten references is appended.

The Action of Sulfuric Acid on an Optically Active Hydrocarbon. ROBERT L. BURWELL, JR. AND GEORGE S. GORDON, III, *Jour. Am. Chem. Soc.* **70** (1948), pp. 3128-32.

(+)3-Methylheptane and 80 mole percent sulfuric acid were agitated together at temperatures between 25 and 70° C. Exchange and racemization occur with the rate of the former being 15 times greater than the latter. Isomerization is slower than racemization. The rate of exchange of n-octane is more than 100 times slower that that of 2- and 3-methylheptane. These results are incompatible with those mechanisms of alkylation of olefins by isoparaffins which involve initial attack by sulfuric acid on the alkane. Possible mechanisms of the racemization-exchange reaction are discussed and a chain reaction with an olefin intermediate regarded as most probable.

MANUFACTURE: PROCESSES AND PLANT

Multicomponent Distillation, Constant Volatility Ratio and Constant Reflux. P. G. MURDOCH, *Chem. Eng. Progress* **44** (1948), pp. 855-62.

The author briefly reviews the status of our present knowledge of methods of calculating the plate and reflux requirements for the distillation of milticomponent systems. The author is of the opinion that the most promising means for increasing knowledge of the general behavior of multicomponent distillation in theoretical-plate columns is afforded by the purely analytical approach, in which the various relationships involved are reduced to algebraic equations. No method for solving this general problem in algebra is known for the general case, but a solution can be obtained if the volatility ratios and the molal reflux are assumed to be constant within the rectifying and stripping sections of the column. Many actual systems approach these conditions closely enough to give the equations practical significance. Algebraic equations were developed by the authors and are applied in three- and four-component separations, as examples, and can, however, be used for any number of components.

Extraction of Polar Constituents from Hydrocarbon Solutions. Field Application in Natural Gas Condensate Wells. D. A. SHOCK AND NORMAN HACKERMAN, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2169-72.

Corrosion in high pressure condensate natural gas wells is believed to be associated with the presence of polar components such as straight-chain carboxylic acids and other types. It was desired to identify these compounds and this, in turn, required a method for concentrating the substances studied. Removal by alkali extraction was too inefficient when done with inexpensive equipment. An attempt was made to remove the sub-

stances by adsorption. Adsorption and recovery of compounds typically found in the system under investigation were studied, using commercial silica gel as the adsorbent. Adsorbates chosen were acetic acid, naphthenic acid, and resorcinol. The results obtained in the laboratory indicated that a sufficient quantity of each could be retained on the gel and then removed by proper treatment so that this procedure is feasible as a field method. A simple apparatus for use in the field is described. Extraction by this method is effective, provided the rate of flow is low and the course of the extraction is followed so that fresh adsorbent can be provided periodically.

High Pressure Laboratory Flow Apparatus. V. N. IPATIEFF, G. S. MONROE AND L. E. FISCHER, *Ind Eng. Chem.* **40** (1948), pp. 2059-62.

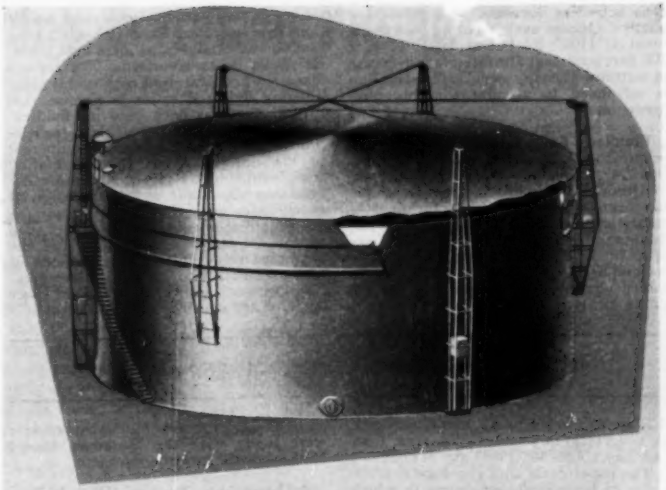
The paper describes a high pressure laboratory flow plant that has given satisfactory results for high pressure reactions, such as the synthesis of methanol from hydrogen and from carbon dioxide and the conversion of benzene and benzene-methane into toluene. The plant was designed to process, catalytically or thermally, normally liquid gaseous materials, or combinations of both at pressures up to 13,000 pounds per square inch and at temperatures up to 565° C. A flow diagram is given and diagrams showing of the furnace and the reaction tube. The operation of the equipment is described.

Color Contamination of Petroleum Products Transported by Pipe Line. L. V. SORG AND R. E. DICKEY, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2163-6.

An internal corrosion inhibitor, consisting of an aqueous solution containing 3 percent sodium hydroxide, 6 percent ammonia, and a wetting agent was used in a field trial to protect a petroleum products pipe-line system originating at Sugar Creek, Mo., and extending to Des Moines, Iowa, and Sioux Falls, S. D. An unexpected color contamination problem was encountered which was particularly objectionable in the case of water-white products such as kerosene. The dye responsible for the discoloration was isolated and identified as p-indophenol. This substance is formed in the alkaline phase and results through the reaction between an oxidation product of the antioxident used in motor fuels and phenol that naturally occurs in petroleum stocks. These compounds are concentrated by the alkaline inhibitor phase. Concentrations of p-indophenol as low as one part in 5 million were found to impart an objectionable pink discoloration to water-white petroleum products. It was found that the addition of sodium sulfite to the corrosion inhibitor would eliminate the color trouble without affecting the corrosion-inhibiting quality of the inhibitor.

Montmorillonite Cracking Catalyst, X-Ray Diffraction. ALEXANDER GRENALL, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2148-51.

X-ray powder diffraction data are presented for the commercial clay cracking catalyst, Filtrol, demonstrating the presence of montmorillonite clay over the catalytically active temperature range. When this phase is thermally destroyed at about 1560° F., the cracking activity, with regard to gasoline production, decreases. When the catalyst is heated in an atmosphere containing steam, cata-



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lytic activities decrease. The diffraction pattern appears unchanged by this treatment at 1100° F., but at 1400° F. in a 100 percent steam atmosphere a decrease in pattern intensity occurs. Explanation is advanced to account for this phenomenon.

Fluidized Solids Pilot Plants. E. W. Nicholson, J. E. Moise, and R. L. Hardy, *Ind. Eng. Chem.* **40** (1948), pp. 2033-9.

Although the fluidized solids technique has been applied largely to the field of catalytic cracking, this method will undoubtedly be used to an increased extent in a number of processes. The technique is particularly adaptable to mixed phase processes requiring the addition or removal of large amounts of heat, especially where isothermal conditions are desirable. Fluidized solids may function as catalysts, as inert heat transfer media or as adsorbents. The authors discuss a practical design of a pilot plant utilizing fluidized solids technique. Apparatus that has been used for fluidization studies is illustrated. The translation of data obtained in such equipment to the design of reactors, circulating equipment, etc., is given. Recommendations are also made as to the design of specific features that are common to most fluidized solids pilot plants, such as the solids-gas distributions and the solids recovery equipment. Methods of measurements and control of temperature, pressure, solids flow rate, and space velocity are considered.

PRODUCTS: PROPERTIES, UTILIZATION AND ANALYSIS

Flow Properties of Asphalt Emulsions. D. V. Lyttleton and R. N. Traxler, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2115-7.

The paper deals with rheological properties of bituminous emulsions in which water is the external phase. A Brookfield viscometer was used in the work. This instrument provides for the use of variable rates of shear and this, in turn, permits rheological studies to be made quickly and easily. Evidence is given that the rate of shear versus absolute consistency of asphalt emulsions is a straight-line relationship when plotted on log-log coordinates. Over 30 emulsions were studied, and each fell into one of three categories, namely "plastic flow," "inverted-plastic flow" or "Newtonian flow." These are given in the order of decreasing frequency of appearance of the type. Data obtained confirm previous indications that asphalt emulsions have low susceptibility to consistency change with change of temperature. Effects of centrifuging on consistency of various types of emulsions are considered. A bibliography of five references is given.

Automatic Distillation Apparatus for A.S.T.M. Method D-86. F. B. Rolfson, C. J. Penther, and D. J. Pompeo, *Analytical Chemistry* **20** (1948), pp. 1014-9.

The article presents a description of an apparatus that automatically plots a complete distillation curve in accordance with the standard A.S.T.M. D-86 procedure. It is only necessary for the operator to fill the distillation flask with liquid, insert the chart paper, and set the initial heat. The apparatus does the distillation, records the required data, such as correct temperature, initial boiling point, end point and distillation rate. When the distillation is complete the apparatus automatically resets itself for the next test. The apparatus is described in detail and typical distillation curves as recorded are given.

Isomeric Xylene and Ethylbenzene Mixtures. Infrared Spectroscopic Analysis. Wilbur I. Kaye and Marshall V. Otis, *Analytical Chemistry* **20** (1948), pp. 1006-8.

A liquid-phase method is given for the quantitative analysis of isomeric xylene and ethylbenzene mixtures in carbon disulfide solvent. The accuracy of the method is about one percent. The absorption coefficient abnormalities of xylene isomers and ethylbenzenes are reported for varying concentrations in carbon disulfide solvent. Measurements were made with the Beckman Model IR-2 infrared spectrophotometer.

A Lamp for Burning High-Boiling Petroleum Fractions. Determination of Hydrogen. S. G. Hindin and A. V. Grosse, *Analytical Chemistry*, **20** (1948), pp. 1050-2.

In lamp procedures developed for the determination of hydrogen, carbon, and sulfur in gasolines, the sample is burned in a lamp and the combustion products are collected and determined. Such methods are eminently suitable for the analysis of low-boiling liquids because the procedure involves combustion of the sample at the end of the wick. However, the lamp method has not been used in the analysis of higher boiling materials because these do not diffuse up the wick at a rate sufficient to insure an adequate supply of liquid for combustion. A modified lamp design which allows extension of the procedure to higher boiling petroleum fractions is described. Accuracy in the determination of hydrogen is of the order of ±0.02 to 0.03 percent hydrogen. Substances as high boiling as 500° C. can be analyzed.

Determination of Oxygenated and Olefin Compound Types by Infrared Spectroscopy. J. A. Anderson, Jr., and W. D. Seyfried, *Analytical Chemistry* **20** (1948), pp. 998-1006.

The investigation was directed largely toward development of a procedure for determining various types of oxygenated compounds and olefins. In complex solutions such as the products from Fisher-Tropsch type synthesis processes, it was found possible to make determinations for the functional groups of alcohols, aldehydes, carboxylic acids, esters, ketones and five different olefin types in a period of about four hours. For oxygenated compound types, the average accuracy ranges from ±10 to ±20 percent. For olefin types, the average deviation is about ±3 equivalent bromine number units. The method can be applied to samples as small as one milliliter, and samples can be analyzed by these procedures that could not formerly be handled even when adequate chemical methods were available. In general, infrared absorption procedures for the determination of compound types are based upon the facts that certain functional groups of a given type absorb infrared radiation at a constant wave-length characteristic of the functional group; and, when expressed on a proper basis, the absorption coefficient for each functional group is essentially constant, regardless of molecular weight. The apparatus and method used is described and numerous data are presented in tabular form. A bibliography of 14 references is included.

Silicia Gel Percolation. Buell O'Connor, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2012-3.

Silica gel percolation can be used as a laboratory method in the study of such materials as synthol, a product of a modified Fisher-Tropsch synthesis. It offers a quick means of determining the classes of compounds contained in synthol to an accuracy of ±2 percent. Furthermore, it offers a convenient method for the separation of small batches of material for further study and when supplemented by the use of an azo dye, it offers a method of determining hydrocarbons and oxygenated materials to an accuracy of ±1 per cent. Greater accuracy in this latter instance results not only from having a more sensitive break point, but also from making summation volume readings only. A bibliography of five references is included.

FUNDAMENTAL PHYSICAL AND CHEMICAL DATA

Thermodynamic Properties of n-Butane. H. William Prengle, Jr., L. R. Greenhaus, and Robert York, Jr., *Chem. Eng. Progress* **44** (1948), pp. 863-8.

Increasing use of light hydrocarbons justifies the evaluation of the basic thermodynamic properties such as enthalpy and entropy. In order that quantitative calculations can be made for the energy effects involved in compressing, condensing, evaporating, throttling, heating, or cooling of pure butane, thermodynamic properties such as enthalpy and entropy are required. The authors have evaluated these properties over a range from the liquid at its normal boiling point to the gas at 540° F. and 300 atm. pressure. The results of the work are presented in tabular and diagrammatic form. A bibliography of 26 references is included.

The Vapor Pressure, Orthobaric Densities and Critical Constants of 2,2,4-Trimethylpentane. James A. Beattie and David G. Edwards. *Jour. Am. Chem. Soc.* **70** (1948), pp. 3382-4.

Vapor pressures and orthobaric densities of 2,2,4-trimethylpentane were determined from 150 to 250° C. These vapor pressures and those of E. R. Smith for 100 and 125° C. fit the equation $\log_{10} p(\text{atm}) = 4.43444 - 1650.17/T$. The critical constants of 2,2,4-trimethylpentane were determined by the compressibility method. $t_c = 271.15 \pm 0.10$ (Int.), $p_c = 25.50 \pm 0.10$ normal atmospheres, $v_c = 0.482$ liters per mole (4.22 ml. per gallon), $d_c = 2.07$ moles per liter (0.237 gallon per ml.). The uncertainty in the critical volume or density is approximately 3 percent. This rather large uncertainty is caused by the rapidity with which this hydrocarbon decomposes with formation of tar at, or near, the critical region.

Critical Constants, Density and Viscosity. Arnold Boas, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2202-3.

The author applies the law of corre-

Reducing Corrosion Pitting

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Corrosion from the water side of Condenser and Heat Exchanger Tubing is one of the biggest problems of petroleum refining, petro-chemical and chemical processing plants, as well as for tankers carrying their products. Since corrosion pitting (deposit attack) is a frequent cause of tubing failure, this type of corrosion should be given special study.

Causes of Corrosion Pitting. In general, most of the trouble is caused by deposits in the Condenser and Heat Exchanger Tubing of such foreign matter as sand, sawdust, mud, stones, coal, coke, cinders, marine growth, rust, etc. The metal beneath or around the deposit of foreign substance or rust is comparatively rapidly attacked while the adjacent areas of metal, which have no deposit, are only slightly corroded. The continued accumulation of corrosion products from the destructive action which takes place on the tube wall helps to produce deeper pits or to enlarge the areas being corroded. Pitting perforates the tube wall within a *much shorter time* than the over-all corrosion rate would indicate.

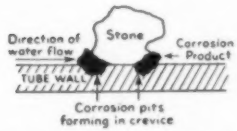


Figure 1. Diagram showing the result of deposit of solid, inert material on condenser tube wall.

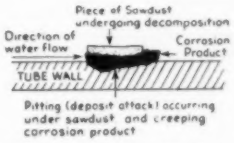

Piece of Sawdust undergoing decomposition
Direction of water flow
Corrosion Product
TUBE WALL
Pitting (deposit attack) occurring under sawdust and creeping corrosion product

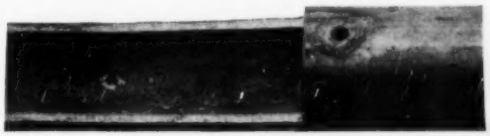
Figure 2. Diagram showing the result of a deposit of porous material on condenser tube wall.

Effect of Solid Deposits. With such substances as shells, stones, coke, coal, etc., corrosion pitting generally does not take place directly beneath the object but rather in the crevices formed where the object comes in contact with the tube wall (see Figure 1). Symmetrical or irregular rings of corrosion pits are formed beneath a layer of corrosion product.

Effect of Porous Deposits. When porous deposits such as bits of wood, cloth, paper, decayed fish, marine growths, rust, etc., are in contact with the tube surface, corrosion pitting may take place quite uniformly beneath the deposit (see Figure 2). Under these conditions, high-zinc alloys, such as Muntz metal for example, may develop plug-type dezincification instead of pits filled with loose corrosion products.

Effect of Temperature and Water Composition. Generally, pitting is accelerated with higher temperatures of the tube wall. In some cases, as water temperature rises, bacterial activity increases, causing formation of such gases as hydrogen sulphide, ammonia, carbon dioxide, etc., which may also accelerate corrosion pitting.

Effect of Alloy Composition. No condenser tube alloy is immune to corrosion pitting. However, this type of corrosion is affected in some waters by alloy composition. For example, with Aluminum Bronze and Aluminum Brass, after pitting has progressed to a certain point, the attack, in some cases, seems to be stifled by the corrosion product developed in the corrosion pits. Cupro Nickel in clean sea water shows a tendency to form broad shallow pits rather than small deep ones.



An excellent example of premature failure caused by corrosion pitting of an otherwise sound condenser tube.

Preventive Measures. Wherever possible, foreign matter should be prevented from entering the condenser or heat exchanger. Baffles in intake tunnels are effective in preventing floating debris. Screens are desirable for keeping out stones, shells, cinders, wood, fish, seaweed, etc. Careful periodic cleaning by various mechanical and chemical procedures is helpful. Once pitting has begun, however, there is no certain method of arresting it. Therefore, it is of vital importance to carry out preventive measures faithfully in order to stop deposit attack from obtaining a foothold. Experience has shown that where tubes are kept clean, pitting can be reduced considerably and the life of tubing greatly lengthened.

Condenser Tube Warehouse Stocks are carried in Los Angeles, San Francisco, and Houston for the convenience of our customers whose needs are so urgent that they cannot wait for mill shipments. Contact the nearest Bridgeport office for your tube requirements and for help in your corrosion problems. Our laboratory will gladly assist in the selection of the alloy which will serve best. Write for 120-page Condenser Tube Manual, containing much information on condenser and heat exchanger tube alloys and duplex tubing, their characteristics and applications.

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CONDENSER AND HEAT EXCHANGER TUBING

sponding states to some equations relating physical properties. Reduced equations are obtained, and thereby, a means of estimating critical constants. Viscosity and density are recommended to be used in estimation of critical densities and temperatures. Samples of the application of the procedure are given and values of the constants as reported in the literature and as calculated are given in tabular form. A bibliography of eight references is included.

Thermodynamic Properties of Benzene. ELLIOTT I. ORGANICK AND WALTER R. STUDHALTER, *Chem. Eng. Progress* **44** (1948), pp. 847-54

Few tabulations of thermodynamic properties of aromatic hydrocarbons have been published, although accurate tabulations of the properties of paraffinic and olefinic hydrocarbons are becoming inc,easingly available to engineers. The recent publication by Hixson and associates, of accurate experimental PVT data for benzene makes possible the computation of the complete thermodynamic network for benzene. The authors make use of the equation of state developed by Benedict, Webb, and Rubin. A pressure-enthalpy diagram is included in the article. A table is presented showing thermodynamic properties of saturated benzene from 100 to 553.1° F. A table is also included showing thermodynamic properties of superheated benzene over wide temperature ranges and from atmospheric pressure of 3000 psi. A bibliography of 14 references is included.

Correlation Vapor Compositions and Related Properties of Solutions. Use of Critical Constants. DONALD F. OTHMER AND ROGER GILMONT, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2118-24.

The authors present a method for expressing pressure, temperature, and vapor and liquid composition data equilibrium as a sheaf of straight lines. Good correlations were obtained through the entire range, including the critical. Lines of constant compositions in the liquid phase are drawn on log paper as a plot of the relative volatilities against the ratios, for a reference substance, of the specific volume of the vapor to the specific volume of the liquid, all at the same value of the reduced temperature. For all binary systems studied, these lines were straight. This permits accurate interpolation, extrapolation and evaluation of experimental data. Other methods of logarithmic plotting with a reference substance are indicated and can be used in some cases, but do not always give the desired straight-line correlation. The results of the work are presented in considerable detail in tabular and graphical form and a bibliography of ten references is included.

Empirical Heat Capacity Equations of Gases and Graphite. HUGH M. SPENCER, *Jour. Ind. Eng. Chem.* **40** (1948) pp. 2152-4.

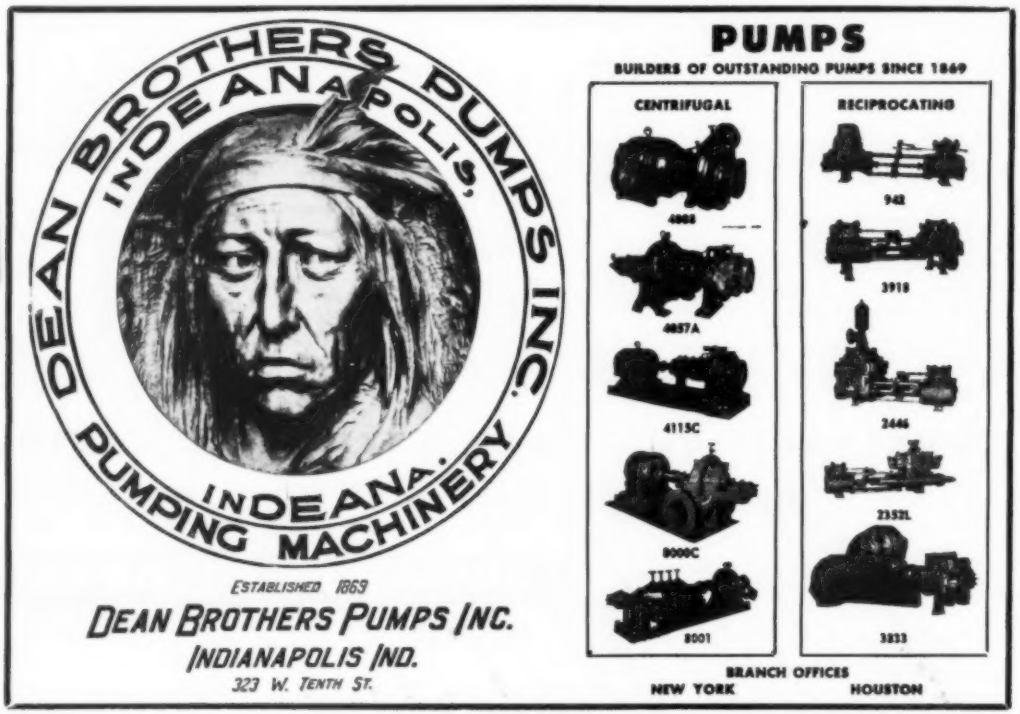
Empirical heat capacity equations were developed for solid graphite and 117 gases in the hypothetical ideal state at one atmosphere, largely for the range 298.16 and 1500° K. The subjects covered include 17 paraffins, 39 mono-olefins, 12 acetylenes, 20 alkylbenzenes, 10 cyclopentanes, and 17 cyclohexanes. Data are given also for a number of miscellaneous compounds. The data are presented in detail in the form of eight tables, and a bibliography of 14 references is included.

Superfractionation Studies. F. G. SCHWARTZ, R. M. GOODING AND B. H. ECCLESTON, *Jour. Ind. Eng. Chem.* **40** (1948), pp. 2166-9.

A naphtha from a Santa Barbara, Venezuela, crude oil was superfractionated, with collections of 0.5 percent fractions and CRC-F-2 and CRC-F-3 octane numbers were determined for each fraction. Analyses of the small fractions, and the engine ratings, provide data for calculating the blending octane numbers of individual hydrocarbons when blended with other hydrocarbons with which they normally are associated. Blending octane numbers can be used to calculate the octane numbers of naphthas having a boiling range from 97 to 243° F., using laboratory superfractionations and refractometric analysis. Above this boiling range compositions become indeterminate, except as to type of hydrocarbon.

Conjugate Liquid Phase Equilibria, C_4-Hydrocarbon-Furfural-Water Systems. JOHN GRISWOLD, M. E. KLECKA, AND R. V. WEST, JR., *Chem. Eng. Progress* **44** (1948), pp. 839-46.

Extractive distillation is a key operation in the purification of butenes and of butadiene in petroleum butadiene plants. Some of the major plants use furfural as solvent and the production rate of such plants is dependent on and usually limited by maximum throughput and performance of the furfural distillation towers. One of the important variables on which tower performance



depends is conjugate liquid phase equilibria of the C_4 hydrocarbon-furfural-water systems handled. The authors present the results of experimental work in the examination of such systems. The apparatus used is a new design for obtaining and observing conjugate liquid phases under pressure. Most of the data in the literature on binary mixtures are fragmentary and of unknown accuracy. Consequently some work on binaries was done in the course of the work reported. Data are presented in considerable detail in tabular and graphical form and a bibliography of 14 references is included.

Mass Spectra of Octanes. E. G. Bloom, F. L. Mohler, J. H. Lengel and C. E. Wise, *J. Research Natl. Bur. Standards*, **41** (1948), pp. 129-33.

The mass spectra of 18 isomers of octane were studied to look for possible correlations between the structure of the molecules and the mass spectra. Data on the sensitivity and total ionization of the octanes as compared with n-butane show that the maximum mass peak in each spectrum is mass 43. Four isomers with a tertiary butyl radical have the maximum mass peak at 57. Molecule ions contained in this group probably have a tendency to split in half. The maximum value for the normal compound is a parent peak of 114, which seems to be a rule for saturated hydrocarbons. The group of octanes containing carbon atoms with two side chains have a much smaller value than 114 and than any of the other octanes. The use of mass spectra for deduction of the structure of complicated molecules is still far from realization because the phenomenon of rearrangement of hydrogen atoms that sometimes occurs during ionization is not understood. The empirical relations indicated in this paper apply with some generality to saturated hydrocarbons but they appear to be mutually inconsistent. The high probability of ionizing a tertiary butyl radical in the octanes almost completely masks the other possible ionization processes.

Gas Technology Fellowship Applications Now Underway

In order to provide the gas industry with young men specially trained in its technology, the Institute of Gas Technology annually awards a number of fellowships to selected college graduates to pursue a two-year course leading to the master's degree in gas technology or a four-year course leading to the doctor degree.

Applications for these fellowships will be accepted until March 15, 1949. Fifteen fellowships paying $125 per month for ten months, with increases in the monthly stipend in following months are available. Tuition and laboratory fees are free and cooperating member companies pay the fellows for work performed during the requisite summer employment training period. Formal appointments will follow the application deadline.

Seniors and graduates under 28, working in chemistry, chemical engineering, mathematics, mechanical engineering and related fields are eligible and are selected on the basis of academic and personal qualifications.

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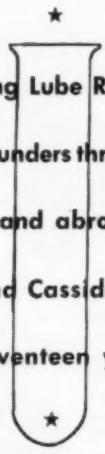

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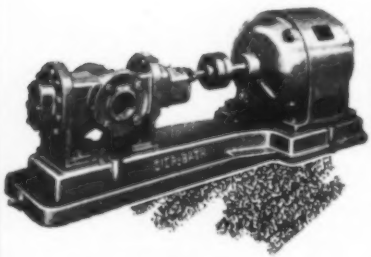

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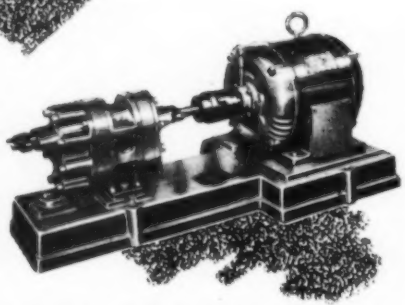

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BOOKS

Commercial Aviation Gas Tests Reported by Bureau

Octane ratings and other characteristics of commercial aviation gasoline marketed in the United States this year by 16 manufacturers are listed in a semi-annual survey by the Bureau of Mines. Based on July, 1948, production, the report covers 66 samples of four grades of aviation gasoline tested in Bureau of Mines laboratories and gives inspection tests data on the same gasolines furnished by the manufacturers.

Laboratory and inspection test results are shown for 19 samples of grade 80 aviation gasoline; 17 samples of 91/98 grade; 22 samples of 100/130 grade; and eight samples of 115/145 grade. The results include characteristics ordinarily listed in aviation-gasoline specifications such as octane and performance numbers, tetraethyllead content, dye color, distillation range, Reid vapor pressure, gravity, heat of combustion, and freezing point.

A free copy of the survey, Report of Investigations 4435, "Survey of Commercial Aviation-Gasoline Characteristics July 1948 Production," may be obtained by writing Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13.

Commercial Standard Fuel Oils Available

Printed copies of *Fuel Oils (Sixth Edition), Commercial Standard CS12-48*, are available, the National Bureau of Standards has announced. Mimeographed copies were released in August.

This is the fifth revision of the Commercial Standard for Domestic and Industrial Fuel Oils, originally established in 1928. The current revision was developed by Technical Committee E, ASTM, Committee D-2, and indorsed by the standing committee for the Commercial Standard. It has been accepted by a large number of refiners, fuel oil users, and testing laboratories. A brief history of the development of this and previous editions of the standard, and a roster of the Standing Committee are included in the pamphlet.

Copies at 10 cents each may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Transmissive Properties Of Tinted Glasses Studied

Information on the transmissive properties of most of the widely distributed makes of tinted lenses is available in the National Bureau of Standards' new circular, *Spectral-Transmissive Properties and Use of Eye-Protective Glasses.*

Results are given of a study of the spectral-transmissive properties of about 200 glasses intended for use as sun glasses or in special industrial operations where injurious amounts of radiant energy are present.

For a copy of the circular write the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., enclosing 20 cents for each copy.

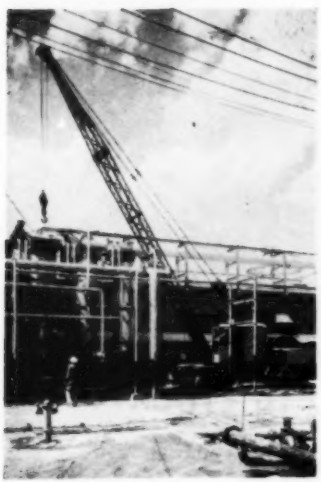
High Polymers Subject For 1948-49 Seminar Series

Chemical and physical properties of high polymers is the subject for the 1948-49 lectures in the series of seminars which have been presented for the past three years at the National Bureau of Standards. Given by the leading scientists in this field, the lectures are open to the public. The program is arranged under the chairmanship of Dr. Robert Simha of the division of organic and fibrous materials.

On October 7 G. Gee of the British Rubber Producers Research Association presented a lecture on "Dielectric and Mechanical Properties at High Frequencies." Following him on November 4 was F. O. Schmitt of the Massachusetts Institute of Technology with "Some Structural and Chemical Properties of Collagen Fibers."

R. S. Spencer of Dow Chemical Company will discuss "Rheological Properties of Polystyrene" on January 6, 1949. On February 24, A. W. Nolle of the University of Texas will present "Some Aspects of Dynamic Rubber-like Elasticity; on March 3 E. W. R. Steacie of the National Research Council will discuss "Reactions of Free Radicals with Hydrocarbons"; C. F. Fryling of Phillips Petroleum Company, on April 7 will discuss "Variables which Influence the Properties of Chemical Rubbers Prepared by Emulsion Polymerization"; and closing the series on May 5 will be W. O. Kenyon of Eastman Kodak Company with "The Chemistry of Some Derived Polymers of the Vinyl Series."

Motorized Crane on Job



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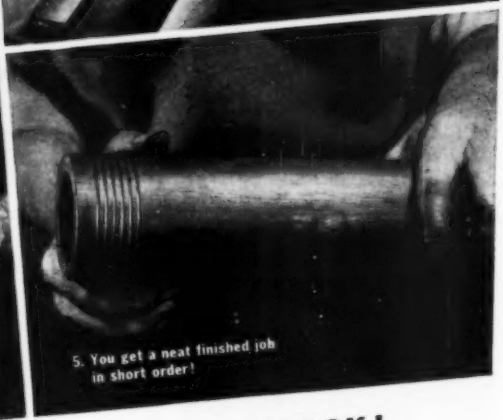

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Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, October 12, 19, 26 and November 2, and 9, 1948.)

REFINING

U.S.P. 2,451,050 Olefin Extraction. C. O. Tongberg to Standard Oil Development Company.

An olefin or diolefin containing mixture of hydrocarbons which have molecular weight differences of 15-30 between the components of highest and lowest mol. wt. is extracted by ammonia and a modifier which increases its solvent power, e.g. methyl amine. The extract formed which contains the olefin or diolefin is passed countercurrently to a paraffinic oil of high boiling range (e.g. with an initial boiling point of at least 450° F.) and a Saybolt viscosity at 100° F. of 80-90 seconds. The paraffinic oil is then separated from the ammonia and modifier and heated to expel the major fraction of the olefin or diolefin. The residual paraffinic oil is stripped with a saturated hydrocarbon boiling within a range of 96-160° F. and higher than the olefin, to obtain as overhead an olefin or diolefin and as residue an olefin-free paraffinic oil.

U.S.P. 2,451,136. Treatment of Normally Gaseous Mixtures. H. H. Wenzke to Universal Oil Products Company.

A gaseous hydrocarbon mixture containing a desired gaseous fraction as well as lighter and heavier components is commingled with a liquid absorbent under superatmospheric pressure. The resulting mixture is cooled to a temperature sufficiently low that the desired fraction and a small amount of lighter gases are retained in the absorbent. The rich absorbent is separated from the undissolved gases which contain a small part of the desired fraction, and the lighter gases are stripped from this rich absorbent by heating and fractionating it. The stripped gases are mixed with the original hydrocarbon mixture and the liquid absorbent prior to cooling. The stripped rich absorbent is fractionated to separate the desired gaseous fraction therefrom. The resultant lean absorbent is countercurrently contacted with the undissolved gases to absorb the small part of the desired fraction. The resultant solution is employed as the liquid absorbent. The desired gaseous fraction can, for example, principally comprise C_3 or C_4 hydrocarbons.

U.S.P. 2,451,327. Removal of Acetylene from Diolefin-Containing Mixtures. E. V. Fasce and W. H. Wood to Standard Oil Development Company.

A gaseous hydrocarbon fraction containing diolefins and acetylenes is passed in the absence of hydrogen at a temperature of 50-300° C. over a bentonite or montmorillonite catalyst previously treated with H_2SO_4, H_2SiF_6, or HF. The acetylenes present are selectively polymerized. The diolefins are recovered from the catalyst substantially free of acetylenes.

U.S.P. 2,451,376. Separation of Olefins from Hydrocarbon Mixtures. G. G. Bernard and D. C. Bond to The Pure Oil Company.

The patent relates to a composition suitable for absorbing olefins. This composition comprises an aqueous solution which contains a tertiary aromatic amine hydrochloride (e.g. dimethyl aniline hydrochloride), free HCl and Cu_2Cl_2. The composition can be employed for concentrating olefins, such as ethylene, in a hydrocarbon gas mixture.

U.S.P. 2,451,433. Hydrocarbon Extraction Apparatus. H. R. Davis to The Lummus Company.

The patent describes and claims the details of a countercurrent extractor for hydrocarbon oils making use of propane to provide predetermined cuts of lubricating oil stock and to remove resins, asphalts, etc.

U.S.P. 2,451,568. Treatment of Hydrocarbons. C. B. Linn to Universal Oil Products Company.

A hydrocarbon material which contains as an impurity a relatively small percentage of organically combined fluorine is contacted at a temperature of 0-150° C. with a liquid mixture of HF and the organic constituents of a sludge resulting from the treatment of hydrocarbons with a sludge-forming hydrocarbon conversion catalyst (particularly a HF-sludge). The said mixture shall contain 40-90 percent of the organic constituents. Hydrocarbon material freed from a substantial proportion of organically combined fluorine is recovered.

U.S.P. 2,451,668. Process and Apparatus for Reconditioning Contaminated Oil. C. J. Egger and R. H. Webster to The Buckeye Laboratories Corporation.

Oil, particularly lubricating oil of petroleum character, contaminated in use by volatile contaminants, is heated and sprayed into an evacuated chamber surrounded by a body of heat transfer fluid which heats and maintains the chamber to at least the boiling point of the contaminant at the reduced pressure. The volatilized contaminant is removed, and purified oil is recovered.

U.S.P. 2,451,896. Distillation of Butane Containing High Boiling Contaminants. G. W. Wilson, Jr., to Standard Oil Development Company.

A primary feed mixture including n-butane, isobutane and a minor portion of higher boiling impurities is subjected to a continuous distillation process to obtain a fraction comprising a major portion of n-butane substantially free from higher boiling hydrocarbons. Details of this process are claimed.

U.S.P. 2,452,489. Motor Fuels. W. A. Partridge and H. J. Alty to Anglo-Iranian Oil Company, Ltd.

Gasoline fuels containing tetraethyl lead are stabilized by the addition of a small proportion (preferably less than 1 percent) of dialkyl sulfate.

U.S.P. 2,452,693. Mineral Oil Compositions Resistant to Foaming. H. G. Smith and T. L. Cantrell to Gulf Oil Corporation.

Mineral oil is compounded with a small amount (e.g. 0.01-1 percent) of a salt formed from a metal, a heterocyclic nitrogen base, or a N-dialkyl-arylamine, and the viscous liquid reaction product of heating to not more than 300° F. one mol of a glycol with 2-6 C atoms, one molar equivalent of $POCl_3$ or P_2O_5, and one mol of a saturated aliphatic monohydric alcohol with 1-18 C atoms. The foaming tendency of the oil is reduced by the additive.

U.S.P. 2,453,138. Process of Deleading Gasoline. M. S. Kharasch to the U. S. Secretary of War.

Gasoline which contains tetraethyl lead is mixed with $SnCl_4$. The mixture is treated with a tertiary-amine-treated charcoal to adsorb the reaction products and settle them out. The gasoline is thus deleaded.

U.S.P. 2,453,205. Controlled Fractional Distillation of Petroleum. P. Docksey to Anglo-Iranian Oil Company, Ltd.

Closely cut high grade fractions of a petroleum distillate are obtained by the fractionation of a petroleum distillate admitted to the column at a determined constant volume rate. The details of the process are described and claimed.

U.S.P. 2,453,593. Apparatus for Separating Entrained Solids from Gases. D. H. Putney to Stratford Development Corporation.

The details of an apparatus for separating entrained solids from gaseous materials are given. The gaseous mass treated is rotated while passing through

a vessel provided with peripheral apertures for the passage of solids and gases.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,451,471. Preparation of a Co-Precipitated Gel Catalyst. R. E. Burk and E. C. Hughes to The Standard Oil Company of Ohio.

The patent claims a particular process of making an aluminum-chromium-molybdenum oxide gel type catalyst by co-precipitation.

U.S.P. 2,451,573. Fluid Catalyst Regenerator System. W. A. Myers and W. A. Hall to The Atlantic Refining Company.

Finely divided solid catalytic material is regenerated by passing an oxidizing gas upwardly through this material at a controlled rate to maintain a dense turbulent layer of this material in the bottom portion of the regenerating zone while maintaining in this zone a temperature sufficient to burn combustible deposits from the solid material. Steam is injected into the stream of regeneration gas, associated with minor amounts of contaminated solid material. The dense layer of the solid material is thus considerably cooled and secondary combustion above this layer is avoided.

U.S.P. 2,453,084. Manufacture of Bead-Form Catalyst. H. T. Brown to Socony-Vacuum Oil Company, Inc.

The patent relates to a continuous process for the manufacture of inorganic oxide spheroidal particles of a desired size range and with adsorbent and catalytic properties, e.g. spheroidal particles of alumina. Details of this process are claimed.

U.S.P. 2,453,458. Catalyst Transfer System. C. S. Reed, A. H. Schutte, and V. O. Bowles to The Lummus Company.

The details of an apparatus for the transfer of a solid catalyst in a divided state between a reaction zone and a reactivation zone with maintenance of a required pressure differential between these zones are given.

U.S.P. 2,453,585. Process of Making a Substantially Alkali-Free Hydrogel Catalyst. J. W. Payne, T. P. Simpson, and J. I. Butzner to Socony-Vacuum Oil Company, Inc.

A hydrosol of silica and alumina containing zeolitic alkali metal is permitted to set to a hydrogel. The details of a method of making an alkali-free silica-alumina gel type hydrocarbon conversion catalyst from this hydrogel are described.

U.S.P. 2,453,668. Electrolytic Method for the Production of Porous Catalytic Metal. M. M. Marisic and T. F. Rutledge to Socony-Vacuum Oil Company, Inc.

A porous catalytic metallic body which consists of a plurality of alternate layers of dense and porous nickel and is useful in the hydrogenation of olefins and other processes, is produced by an electrodepositing process described in detail.

CRACKING AND REFORMING

U.S.P. 2,451,041. Catalytic Cracking and Refining Process for the Production of Aviation Gasoline. E. V. Murphee to Standard Oil Development Company.

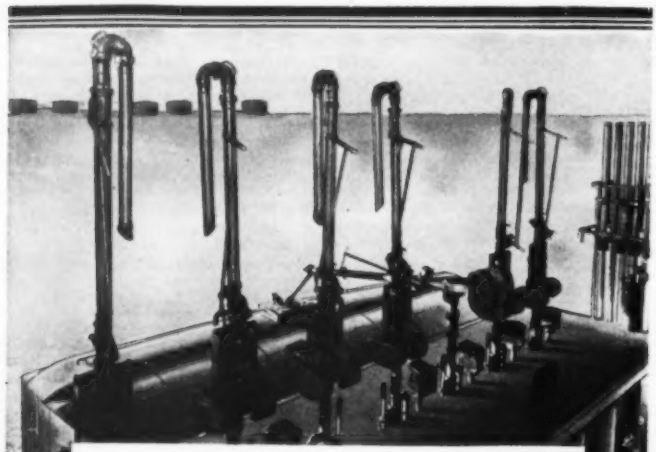
A gas oil is catalytically cracked, preferably in the presence of a synthetic alumina-silica gel catalyst. A fraction boiling in the gasoline range is recovered and reformed at elevated temperatures in the presence of added hydrogen and a dehydrogenation catalyst which comprises 10 percent of a metal oxide of the VI group of the periodic table, such as MoO_3, and 90 percent of a zinc spinel base. The cracked gasoline is converted to a product of low acid heat and increased aromaticity and isoparaffinicity without net consumption of hydrogen.

U.S.P. 2,451,375. Conversion of Hydrocarbons. R. T. Bell to The Pure Oil Company.

Hydrocarbons are subjected to cracking conditions in the presence of an ester of an oxygen-containing phosphorus acid, e.g. an octyl ester, and of halogen, hydrogen halide, carbon tetra halide, or an organ- halogen compound. By the use of such ensitizers the yield of motor fuel from higher boiling hydrocarbon oils is increased and the octane number of the cracking products is improved.

U.S.P. 2,451,924. Apparatus for Contacting Solids with Gaseous Reactants. J. A. Crowley, Jr., to Socony-Vacuum Oil Company, Inc.

An apparatus for accomplishing the introduction of particle form solid material to reaction vessels wherein gaseous reactants are contacted with the moving solid material particles is de-



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scribed and claimed. It is particularly useful in the cyclic cracking of hydrocarbons, such as gas oils, which are converted in a first vessel in the presence of a particle form catalyst whereupon the contaminated catalyst is regenerated in a second vessel and then recycled to the first vessel.

U.S.P. 2,452,172. Method for Catalytic Cracking of Hydrocarbon Oils. H. B. Willard to Gulf Oil Corporation.

In the continuous conversion (e.g. cracking) of hydrocarbons by passing a hydrocarbon stream through a moving bed of solid catalyst continuously supplied to the top of the bed, the space velocity of the hydrocarbons through this bed is reduced by increasing the volume of the bed as the activity of catalyst entering the bed diminishes without interrupting the flow of hydrocarbons therethrough. Uniform operating conditions are maintained throughout the process and a uniform rate of conversion and yield of products is obtained.

U.S.P. 2,453,152. Catalytic Conversion of Hydrocarbons. G. A. Mills to Houdry Process Corporation.

Normally liquid hydrocarbons are contacted under cracking conditions with a surface active catalyst consisting of silica and urania and formed by coprecipitation of colloidal silica and urania in an acid menstruum. High octane gasoline is obtained.

U.S.P. 2,453,592. Contacting Apparatus for Catalytic Processes. D. H. Putney to Stratford Development Corporation.

In order to intimately mix a solid pulverulent catalyst with fluid reactants, the catalyst is circulated in a ring during mixing. The details of an apparatus suitable for attaining this effect are described and claimed.

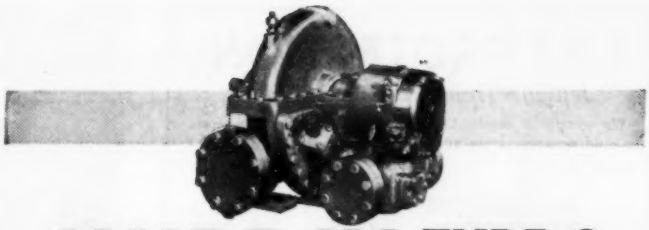
U.S.P. 2,453,641. Method of Producing Colloidal Fuel. C. S. Reed to The Lummus Company.

A mixture formed from finely divided coke particles of petroleum origin and reduced crude bottoms is continuously passed through a cracking zone and heated therein to a cracking temperature sufficient to deposit some petroleum coke on the finely divided coke particles but insufficient to form a completely dry coke. Volatile materials liberated are removed. The treated bottoms are then separated into a liquid and a coke paste fraction. The liquid fraction is blended with an amount of the coke paste fraction sufficient to produce a colloidal fuel of desired viscosity. A portion of the separated coke paste fraction is continuously recycled through a mill and thence into the feed stream of reduced crude bottoms.

ISOMERIZATION

U.S.P. 2,451,018. Method of Preparing an Isomerization Catalyst for Normal Paraffins. R. E. Burk to The Standard Oil Company of Ohio.

A catalyst for the isomerization of normal paraffins, such as n-butane, is prepared by mixing liquid HF and BF_3 under a partial pressure of 5-550 psi. in contact with a n-paraffin to be isomerized and ½-25 percent (by weight of the paraffin) of an olefin, such as butene. The amount of the olefin shall



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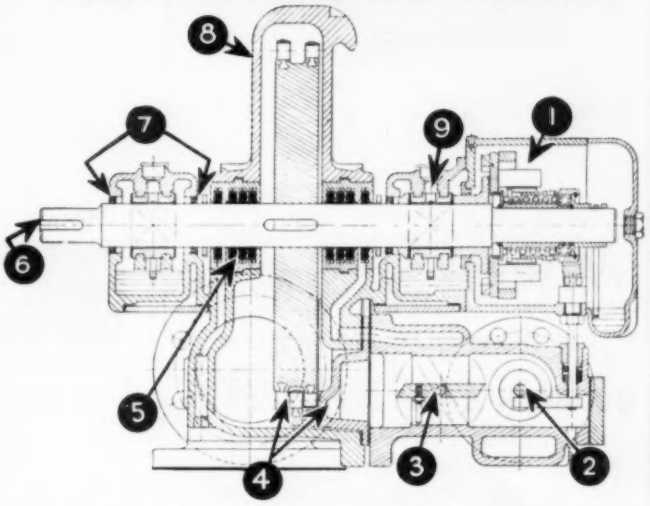

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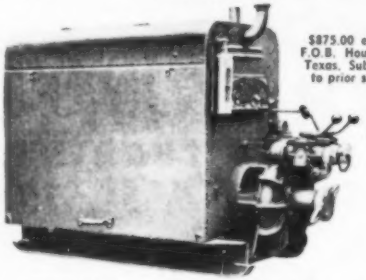

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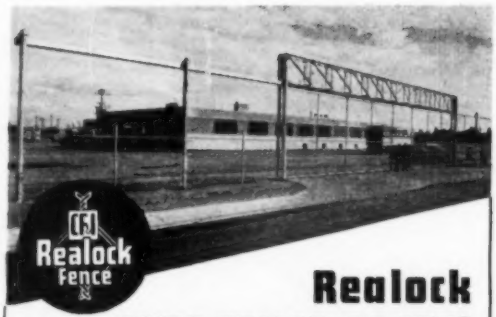

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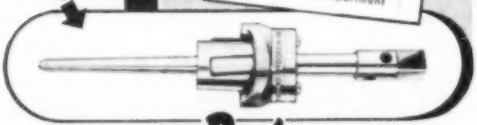

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merely be sufficient to modify the catalytic activity of the fluorides in the isomerization. Superior results are obtained with the olefin containing catalyst.

U.S.P. 2,452,691. Isomerization of Paraffinic Hydrocarbons. B. H. Shoemaker to Standard Oil Company of Indiana.

Normal paraffin hydrocarbons with four and five C atoms are contacted with a Friedel-Crafts catalyst under isomerization conditions in the presence of 0.02-3 percent by volume (based on the hydrocarbon charge) of an aromatic hydrocarbon, such as benzene. This additive substantially inhibits cracking during isomerization of the hydrocarbons.

ALKYLATION

U.S.P. 2,452,017. Method of Mixing Alkylation Reactants. J. B. Middleton to Socony-Vacuum Oil Company, Inc.

One portion of the reaction mass resulting from the alkylation of an olefin with an isoparaffin in the presence of a liquid acid catalyst is separated from the alkylation product while a second portion is mixed with fresh reactant and catalyst and then returned to the reaction zone. The particular method of admixing the catalyst and reactants with this second portion of the reaction mass is claimed.

U.S.P. 2,452,018. Alkylation Process. J. B. Middleton to Socony-Vacuum Oil Company, Inc.

The process of this patent is related to that of U. S. patent 2,452,017. A relatively large body of a mixture of alkylatable hydrocarbon and liquid alkylation catalyst, e.g. anhydrous HF, is maintained under alkylating conditions in the reaction zone while agitating. The alkylating agent is introduced into this mixture through an orifice which is moved at high speed through the mixture, in order to effect rapid dispersal of the alkylating agent throughout this mixture.

U.S.P. 2,452,166. Alkylation of Isobutane with Ethylene. H. E. Vermillion to The Texas Company.

Isobutane is continuously alkylated with ethylene in the presence of an anhydrous liquid HF catalyst containing a minor proportion of BF_3. Details of a particular process of this type are claimed. The resulting product contains at least 65 percent by vol. of 2,3-dimethylbutane.

POLYMERIZATION AND CONVERSION

U.S.P. 2,451,047. Polymer Recovery from Low-Temperature Polymerization of Olefinic Material. A. C. Skooglund and C. C. Swoope to Standard Oil Development Company.

A liquid solution of olefin hydrocarbon with four to ten C atoms is cooled to a temperature of —40° to —164° C. in the presence of a solvent for both the olefin and its polymer and polymerized by addition of a Friedel-Crafts catalyst. The cold polymer solution formed is jetted at a temperature of 80-90° F. and a pressure of 400-500 psi. into intimate

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admixture with an aqueous alkaline solution to produce turbulent mixing in order to hydrolize the catalyst, whereafter the polymer is separated from the alkaline solution.

U.S.P. 2,451,180. Catalysts for the Polymerization of Butadiene-1,3 Hydrocarbons. W. D. Stewart to The B. F. Goodrich Company.

To the water of an emulsion containing water and a lesser amount of polymerizable material comprising a butadiene-1,3 hydrocarbon a simple ionizable salt of a metal of group VIII or the first long period of the periodic table, such as Fe, Ni, Co, Pd, Os, Pt, is added in an amount of 0.00001-0.05 percent by weight of the polymerizable material. The salt employed shall be capable to dissolve in water at least to the extent of 0.1 g. in 100 cc. at 20° C. By polymerizing the butadiene-1,3 hydrocarbon in this manner, the rate of polymerization is substantially increased.

U.S.P. 2,451,564. Treatment of Hydrocarbons with Activated Magnesium Silicates. W. A. LaLande to Attapulgus Clay Company.

Petroleum hydrocarbons are contacted at a temperature of 700-1150° F. with a catalyst which comprises a water-insoluble Mg-silicate activated by treatment with an ammonium compound (e.g. NH_4Cl) in aqueous solution at a temperature of 150-400° F. Conversion of petroleum hydrocarbons into motor fuel can be effected by this operation.

U.S.P. 2,451,619. Catalytic Conversion Process. R. J. Hengstebeck and R. S. McDaniel to Standard Oil Company of Indiana.

The patent relates to a process for the catalytic conversion of hydrocarbons by fluidized solid catalyst and to the regeneration of this catalyst after stripping. While one stream of hot regenerated catalyst is passed from the regeneration zone to the conversion zone, another stream of the same regenerated catalyst is passed directly from the regeneration zone to the stripping zone. Catalyst from this second stream is intermingled with catalyst from the conversion zone in the upper part of the stripping zone. The mixed catalyst thus obtained is stripped and returned from the base of the stripping zone to the regeneration zone. Excellent heat transfer is effected and overheating of the catalyst is avoided.

U.S.P. 2,451,803. Method of Contacting Solids and Gases. D. L. Campbell, H. Z. Martin, and C. W. Tyson to Standard Oil Development Company.

In a process for the conversion of hydrocarbons by passing them in gaseous form through a body of finely divided solid contact material, the contact material is subjected to positive pressure for its introduction into the conversion zone. A gaseous fluidizing agent is introduced into the column of contact material before the latter is fed to the conversion zone. Details of the process are described and claimed. The method is useful also in treating solids with gases for other purposes.

U.S.P. 2,451,804. Method and Apparatus for Contacting Solids and Gases. D. L. Campbell, H. Z. Martin, E. V. Mur-

phree, and C. W. Tyson to Standard Oil Development Company.

The method according to this patent makes use of about the same principle as the process of U. S. patent 2,451,803 for the conversion of hydrocarbon oils which are passed in a confined stream at elevated pressure upwardly through an enlarged conversion zone under such condition that a relatively dense phase of oil vapor and catalyst is maintained therein.

U.S.P. 2,452,190, 2,452,198. Polymerization of Olefins. S. J. Hetzel and R. M. Kennedy to Sun Oil Company.

Ethylene is polymerized according to U. S. patent 2,452,190 by contact under suitable conditions with a catalyst consisting of silica gel, alumina and Ni or Co. Considerably lower temperatures and pressures than have previously been customary are required when using this catalyst.

According to U. S. patent 2,452,198 the same type of catalyst is employed in the polymerization of olefins with three or more C atoms. The catalyst in this case shall consist of 80-99.98 percent by weight of silica gel, 0.01-10 percent alumina, and 0.01-10 percent Ni or Co.

U.S.P. 2,452,569. Process of Treating Hydrocarbons in Presence of Hot Contact Masses. E. J. Houdry to Houdry Process Corporation.

A plurality of separate contact masses is alternately subjected to on-stream conditions for effecting conversion of a hydrocarbon charge and to regeneration by burning carbonaceous deposits. The amount of heat stored in the contact mass during regeneration is to be in excess of that required for the hydrocarbon conversion. A hot stream of the charge passes in succession through the separate contact masses at the desired conversion temperature. Additional, comparatively cool hydrocarbon charge is admitted to the hot stream during its movement between at least one pair of adjacent contact masses to utilize excess stored heat. The process is particularly useful to effect endothermic catalytic conversions, e.g. cracking, of hydrocarbons.

U.S.P. 2,452,812. Prevention of Corrosion in Hydrogen Fluoride Catalytic Organic Reactions. A. Wachter to Shell Development Company.

Corrosion of metal-containing surfaces of a reaction zone for the conversion of hydrocarbons in the presence of a HF catalyst is inhibited by injecting into the reaction zone at a plurality of points a halide of a metal of groups IV and V of the periodic table, e.g. a fluoride of Sb, As, or Bi.

U.S.P. 2,453,044. Process for Producing Cyclopentadiene and its Homologues. C. E. Staff to Carbide and Carbon Chemicals Corporation.

A stream of superheated vapors of the dimers of cyclopentadiene and/or alkyl cyclopentadienes or of a hydrocarbon mixture containing them as obtained by high temperature vapor phase pyrolysis of a mixture of lower paraffins, is dispersed in an inert non-liquid fluid diluent, such as superheated steam, and is continuously passed through a depolymerization zone at a temperature between 200° C. and the temperature at which substantial decomposition of the corresponding monomer occurs. The resulting monomer vapors are rapidly removed to inhibit further polymerization.

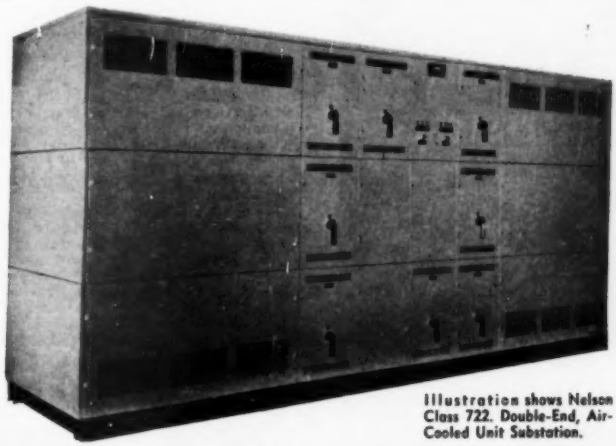
U.S.P. 2,453,327. Hydrocarbon Conversion. E. T. Layng and F. T. Suman, Jr., to The M. W. Kellogg Company.

Hydrocarbon is contacted at elevated temperature with a catalyst consisting of a major proportion of an alumina carrier, a minor proportion of an activating oxide of a metal of the left-hand columns of groups V and VI of the periodic table, and a minor proportion of titanium oxide. The carbon-forming tendency of the catalyst is substantially reduced by the presence of titania without a decrease in catalytic activity for promoting the desired hydrocarbon conversion.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,451,879. Hydrocarbon Synthesis. W. G. Scharmann to Standard Oil Development Company.

A gaseous mixture of CO and H_2 is contacted in at least two reaction zones with fluidized masses of powdered catalyst under conditions of temperature and time suitable for the synthesis of hydrocarbons. The catalyst in the first re-



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action zone is maintained substantially free of oily and waxy material by continuously withdrawing catalyst from this zone and charging it to a second reaction zone. In this second zone the catalyst is simultaneously subjected to a higher temperature than in the first zone to remove oily and waxy materials by volatilization. Gaseous hydrocarbons from the first reaction zone are discharged into the second zone to augment volatilization therein. Thus cleansed catalyst from the second zone is returned to the first zone. The process works continuously.

U.S.P. 2,451,040. Process for Production of Butadiene. E. V. Murphree to Standard Oil Development Company.

Butylene preheated to a temperature of 1200° F. is intimately mixed in an injector pump with steam superheated to 1400° F. The resulting mixture is passed through a catalyst comprising MgO, Fe_2O_3, CuO and K_2O. The reaction product is quenched to 1000° F. immediately upon leaving the catalyst. Butadiene is recovered.

U.S.P. 2,452,121. Conversion of Synthetic Hydrocarbons Containing Oxygenated Compounds to Hydrocarbons of High Octane Value. J. H. Grahame to The Texas Company.

The products of a Fischer-Tropsch hydrocarbon synthesis by the interaction of CO and H_2 in the presence of an iron-group catalyst are subjected to a temperature of 200-300° F. and a pressure of 150-550 psi. Immiscible condensate phases are formed which comprise a hydrocarbon-rich fraction and a water-rich fraction. The first named fraction is passed in vapor phase at a temperature of 700-900° F. into contact with an alumina-containing catalyst to obtain a hydrocarbon fraction of improved octane value.

U.S.P. 2,452,634. Fischer-Tropsch Synthesis Gas from Oil Shale. A. Clark to Phillips Petroleum Company.

Synthesis gas for the Fischer-Tropsch process is obtained by partial combustion of oil shale. The hot spent shale is utilized to bring the temperature of a mixture of hydrocarbon gas e.g. methane, CO_2 and/or steam by heat exchange up to a point where synthesis gas is produced from this mixture.

U.S.P. 2,452,712. Method of Producing Hydrocarbon and the Like. H. V. Atwell to The Texas Company.

In the synthesis of hydrocarbons and oxygenated hydrocarbons from a mixture of CO and H_2 in the presence of a solid synthesis catalyst a desiccant material is continuously passed through the conversion zone. This desiccant chemically combines with water produced to form a compound the dissociation pressure of which under the conversion conditions of the charge is substantially less than the partial pressure of water in the conversion zone. The water-laden desiccant is continuously removed and regenerated.

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U.S.P. 2,451,817. Process for Regenerating Spent Aqueous Alkaline Solution. L. C. Fetterly to Shell Development Company.

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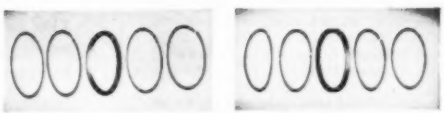

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contains mercaptans from the extraction of hydrocarbons is treated for regeneration with a gas containing free oxygen, in the presence of a phenolic oxidation catalyst, in order to oxidize the mercaptans to organic disulfides. The catalyst is capable of a reversible oxidation reaction and subject to non-reversible oxidation by oxygen in an alkaline solution in the absence of a protecting reducing agent. Examples of such catalyst are tannin, pyrogallol, or picramic acid. An inorganic sulfide sulfur content of at least 0.1 percent by weight of sulfide sulfur sufficient to protect the catalyst from non-reversible oxidation is maintained dissolved in the solution during the treatment.

U.S.P. 2,453,067. Method for Reducing the Mercaptan Sulfur Content of Hydrocarbon Oils. J. Happel and S. P. Cauley to Socony-Vacuum Oil Company, Inc.

A light petroleum fraction containing mercaptans is contacted with an aqueous alkali metal hydroxide which contains a solubility promoter other than tannic acid, e.g. alkali metal cresylate or isobutyrate and a small amount of tannic acid. The ability of the hydroxide to dissolve and thus to remove mercaptans from the petroleum is increased by the additives.

HEAVY OILS AND WAXES

U.S.P. 2 451,025. Method of Refining Lubricating Oils. H. L. Ellender to Standard Oil Development Company.

A mineral oil comprising lubricating oil fractions and organic acids, e.g. a lubricating oil distillate derived from naphthenic acid and mixed base crude petroleum oils, is neutralized by intimate contact with an alkaline reagent. The neutralized oil is continuously distilled to form a lubricating oil distillate. The amount of alkaline reagent is adjusted to obtain a distillate with a neutralization value of about 1.0 mg. of KOH per gram of distillate. The distillate is extracted with phenol. An improved lubricating oil is recovered from the raffinate phase formed.

U.S.P. 2,451,037. Lubricating Oil. R. F. McCleary and S. M. Roberts to The Texas Company.

The mineral lubricating oil according to this patent is compounded with a small proportion of an oil-miscible mono-nuclear aromatic methylene thioether which contains at least one substituent linked to an aromatic nucleus and formed by a sulfhydryl radical or a metal salt thereof, such as an alkyl thiophenol methylene thioether or a metal salt thereof, a mercaptan or metal mercaptide of a mono-nuclear aromatic methylene thioether. A sulfurized additive with anti-corrosive properties, such as a sulfurized fatty oil, can be incorporated. The first named type of additive serves to stabilize the oil.

U.S.P. 2,451,039. Lubricant. A. J. Morway and J. C. Zimmer to Standard Oil Development Company.

The patent relates to a lubricating grease composed of a major proportion of a low pour point mineral oil distillate, a minor, thickening proportion of a Li-soap of a saturated fatty acid and a still smaller proportion of an Al-soap of a saturated fatty acid.

U.S.P. 2,451,048. Lubricating Oil Addition Agent. W. J. Sparks and D. C. Fields to Standard Oil Development Company.

An additive for hydrocarbon oil is prepared from an unsaturated high molecular weight hydrocarbon polymer material of particular properties with 0.5-10 parts isobutylene or butadiene at a temperature of —20° to +40° C. in the presence of a metal halide polymerization catalyst, such as $TiCl_4$ or $SnCl_4$, in a highly dispersed fluid state. The additive causes improvement of the viscosity temperature relationship and of the "oiliness" and reduction in the pour of mineral lubricating oils.

U.S.P. 2,451,345, 2,451,346. Compounded Lubricating Oil. J. G. McNab and D. T. Rogers to Standard Oil Development Company.

A hydrocarbon material which is subjected to deterioration by atmospheric oxygen, e.g. a mineral lubricating oil, is stabilized according to U. S. patent 2,451,345 by an addition of a product obtained by reacting a sulfide of P with a divalent group II metal salt of a compound of the structure $R—Ar(XH)—Y_x—R'$ in which the groups R,XH and $Y_x—R'$ are all connected to the aromatic nucleus Ar, and in which R represents at least one alkyl group of 4-24 C atoms, R' an aryl group, X is O or S, and Y is an element of the sulfur family, while x is an integer of 1-4. This reaction is effected by heating at a temperature of 100-200° C. for a period of at least ten minutes. 0.03-2 atomic proportions of P

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When the weighted pendulum of this valve is released, there's not a moment of delay—the valve action is immediate and positive . . . the flow is full and unimpeded . . . there's no danger of sticking, binding or wedging.

And here's another important feature . . . the weighted pendulum can't damage the valve from impact at the bottom of its swing. No stop is needed to arrest the falling weight, because it disengages from the valve mechanism when its action is completed.

These valves are made in all sizes from 1 in. to 8 in., in metals to meet service conditions, and may be arranged for thermostatic, electrical or manual control from any location. Write for Bulletin E-52C describing these valves in detail.

Opening Type Fig. 4721
For diversion of water to sprinkler deluge or water curtain system or to divert inflammable liquids to a point of safety.

Closing Type Fig. 4831
For emergency shut-off of inflammable liquids or to divert water or steam to fire mains.

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Trade mark "EVERLASTING"—Reg. U. S. Pat. Off.

EVERLASTING VALVES GIVE "EVERLASTING" SERVICE

GOT A
MIXER PROBLEM

BUY
Eastern

Food, chemical and petroleum processing industries find Eastern industrial mixers the answer to many mixing problems. Eastern mixers blend and mix economically over long periods of service. Every Eastern mixer is factory pretested for precision and performance. All are guaranteed by the manufacturer.

MODEL H-1
Heavy duty
¼ H.P.
High speed
1725 R.P.M.
30" shaft
dual 4" low
pitch props.

Available in models from 1/20 to 5 H.P. Motors are sleeve-bearing; totally or semi-enclosed or explosion proof. Screw clamp or bracket mounting. Stainless steel shaft; nickel plated bronze props. Easy to clean, dependable and maintenance-free.

WRITE FOR COMPLETE DETAILS

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INDUSTRIES, INC.
1001 REGENT STREET
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shall be present in the reactants for each atomic proportion of metal.

According to U. S. patent 2,451,346 the stabilizing additive employed is obtained by reacting a sulfide of P with a basic polyvalent metal salt of an acidic organic compound under similar conditions. Phenol or alkyl phenols can, for example, be used as the acidic organic compounds.

U.S.P. 2,451,545. Dewaxing of Hydrocarbon Oils. S. W. Ferris to The Atlantic Refining Company.

An oil-wax mixture is commingled with a solvent and a cerophile (i.e. a liquid which preferentially wets the solid wax and permits it to pass from the oil-solvent phase into this liquid to form a suspension of solid particles therein) at a temperature at which the wax is solidified. The solvent comprises a mixture of toluene, nitrobenzene, and o-nitrotoluene, and the cerophile comprises a liquid paraffinic hydrocarbon. Two immiscible liquid phases of different specific gravity are formed of which the lighter one comprises the cerophile and the solidified wax while the heavier one comprises the solvent and oil substantially free of solidified wax. Wax and wax-free oil are recovered.

U.S.P. 2,451,592. Method of Determining the Rust-Preventing Properties of Lubricants. C. H. Van Hartesveldt to The Atlantic Refining Company.

To determine the rust-preventing properties of lubricant compositions, a ferrous metal test piece is first subjected to the action of exhaust gas products of an internal combustion engine. This test piece is then coated with the lubricant to be tested. The coated piece is exposed to moisture laden air.

U.S.P. 2,451,642. Viscous Mineral Oil Compositions. R. W. Watson to Standard Oil Company of Indiana.

The composition according to this patent comprises a viscous mineral oil and 0.001-0.5 percent of N, N'-dibenzyl-paraphenylene diamine. Oxidative deterioration of the mineral oil in the presence of metal is inhibited by the additive.

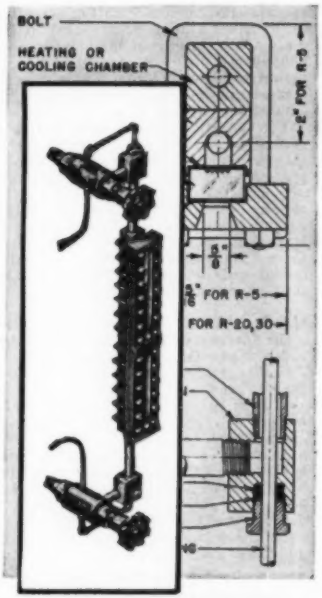
U.S.P. 2,451,874. Corrosion Inhibiting Composition. W. G. Routson to Shell Development Company.

The composition comprises a major amount of a liquid hydrocarbon and a small amount of an organic sulfone of the formula

$$R^1-SO_2-CHR^2-(\underset{|}{C})_n-X$$

wherein R^1 is an aryl radical a nuclear atom of which is directly connected to S, R^2 is an alkyl, aralkyl, or cycloalkyl radical with a long alkyl chain, X is a carboxyl radical or a metal salt thereof, and n plus one is an integer of 1-4. The $CHR^2-(\underset{|}{C})_n-X$ portion of the sulfone shall have a minimum of ten C atoms to render the sulfone oil-soluble. The additive inhibits corrosion. Examples of the additive are: alkaline earth salts of an alpha aromatic sulfonyl derivative of a carboxylic acid with at least 12 C atoms, and alpha phenyl (or tolyl) sulfonyl stearic acid.

U.S.P. 2,452,319. Rust and Oxidation Inhibited Lubricating Compositions. J. A. Patterson and H. D. Kluge to



JERGUSON HEATED AND COOLED GAGES
Give Accurate Readings Under All Conditions

USE Jerguson Heated Gages for accuracy if you are dealing with high viscosity liquids that flow sluggishly.

On the other hand, if you are dealing with highly volatile liquids which tend to boil, use Jerguson Cooled Gages with circulating cooling medium.

In either case, Jerguson engineers have the answer, with a complete line of gages that give accurate reading of *all* liquids under *all* temperature conditions.

Jerguson Heated-Cooled Gages are made in internal tube and double chamber models for all pressures.

Illustration shows Internal Tube Model, Reflex Type, with No. 93 Valves. Write for Data Unit No. 17.

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GAGE & VALVE
COMPANY
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Representatives in Major Cities
Those Listed Under JERGUSON

The Texas Company.

A lubricating mineral oil is compounded with 0.01-5 percent by weight of an alkyl substituted diamino diphenyl methane, 0.005-3 percent of an oil-miscible dicarboxylic acid with at least ten C atoms and a plane symmetric configuration, and 0.0001-2.5 percent of an oil-miscible alkyl acid phosphate with at least ten C atoms in its alkyl portion. The composition has superior anti-oxidant and anti-rusting properties in the presence of water.

U.S.P. 2,452,320. Oxidation-Inhibited Lubricating Compositions. H. D. Kluge and J. A. Patterson to The Texas Company.

The composition according to this patent differs from that of U. S. patent 2,452,319 essentially in that an alkyl substituted diamino diphenyl alkane with one to five C atoms in the alkyl group is employed, the alkane of which can be ethane instead of methane. An alkyl maleic acid with at least ten C atoms is the preferred dicarboxylic acid here employed. Addition of the phosphate is not required in this case.

U.S.P. 2,452,321. Rust Preventive Composition. H. D. Kluge and J. A. Patterson to The Texas Company.

The composition according to this patent differs from that of U. S. patent 2,452,319 essentially in that the alkane additive is not required here, and that the amount of dicarboxylic acid employed is 0.01-3 percent.

U.S.P. 2,453,153. Lubricating Grease. A. J. Morway and J. C. Zimmer to Standard Oil Development Company.

A semi-solid to solid lubricating grease is formed from lubricating mineral oil and 5-20 percent by weight (based upon the finished composition) of acetylene black.

PETROCHEMICALS

U.S.P. 2,451,485. Production of Unsaturated Carboxylic Compounds. G. W. Hearne and M. L. Adams to Shell Development Company.

A gaseous mixture comprising on olefin with at least three C atoms, such as propylene or n-butylene, and oxygen is contacted with a solid Cu_2O catalyst. Unsaturated aldehydes or ketones, such as acrolein, or methyl vinyl ketone are produced.

U.S.P. 2,451,536. Diallyl Diglycolate-Styrene Copolymer. M. E. Cupery and H. S. Rothrock to E. I. du Pont de Nemours and Company.

An interpolymer of diallyl diglycolate and styrene is claimed wherein the ratio by weight of the ester to styrene is at least 2:98. It forms an insoluble and infusible, tough and pliable, scratch resistant coating.

U.S.P. 2,451,612. Preparation of Unsaturated Fluorohydrocarbons. H. D. Coffman and L. F. Salisbury to E. I. du Pont de Nemours and Company.

A mixture of monovinylacetylene or monomethylvinylacetylene and HF is contacted in the vapor phase under anhydrous conditions with a catalyst which comprises an oxide of Hg. The acetylene compound employed is mixed with HF only at the time of contact with the catalyst. Unwanted side-reactions and plugging of the feedline to the reactor are thus prevented.

U.S.P. 2,451,821. Chlorination of Paraffinic Hydrocarbons. E. Gorin to Socony-Vacuum Oil Company, Inc.

A hydrocarbon gas stream which consists essentially of paraffins of not more than two C atoms and comprises not more than 15 mol percent of ethane is contacted with $HgCl_2$ vapor at a temperature of 500-650° C. for sufficient time to convert at least 35 percent and not more than 90 percent of the $HgCl_2$ to free Hg. At least a part of the hydrocarbon is chlorinated with formations of HCl.

U.S.P. 2,451,843. Manufacture of Fluoroalkanes. C. B. Linn and L. Schmerling to Universal Oil Products Company.

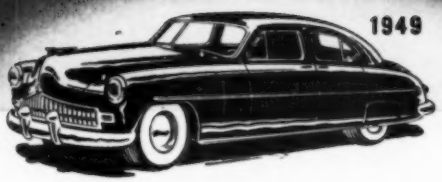
A mixture of ethylene, isobutylene and HF which may also contain isobutane is reacted at a temperature of from —50° to +100° C. 1-fluoro-3,3-dimethylbutane is obtained. A hydrocarbon alkylate can also be formed.

U.S.P. 2,451,869. Catalyzed Oxidation Processes. J. C. Rapeau and W. E. Ross to Shell Development Company.

Vapors of a saturated aliphatic hydrocarbon with at least two C atoms are treated in the presence of HBr at elevated temperature below that at which spontaneous combustion occurs. The walls of the reaction vessel or its inner surfaces are of a hard glass, such as Pyrex glass, and are pre-treated with an inorganic oxygen-containing acid of ni-

To Serve Progress—

Ethyl gives refiners' point of view

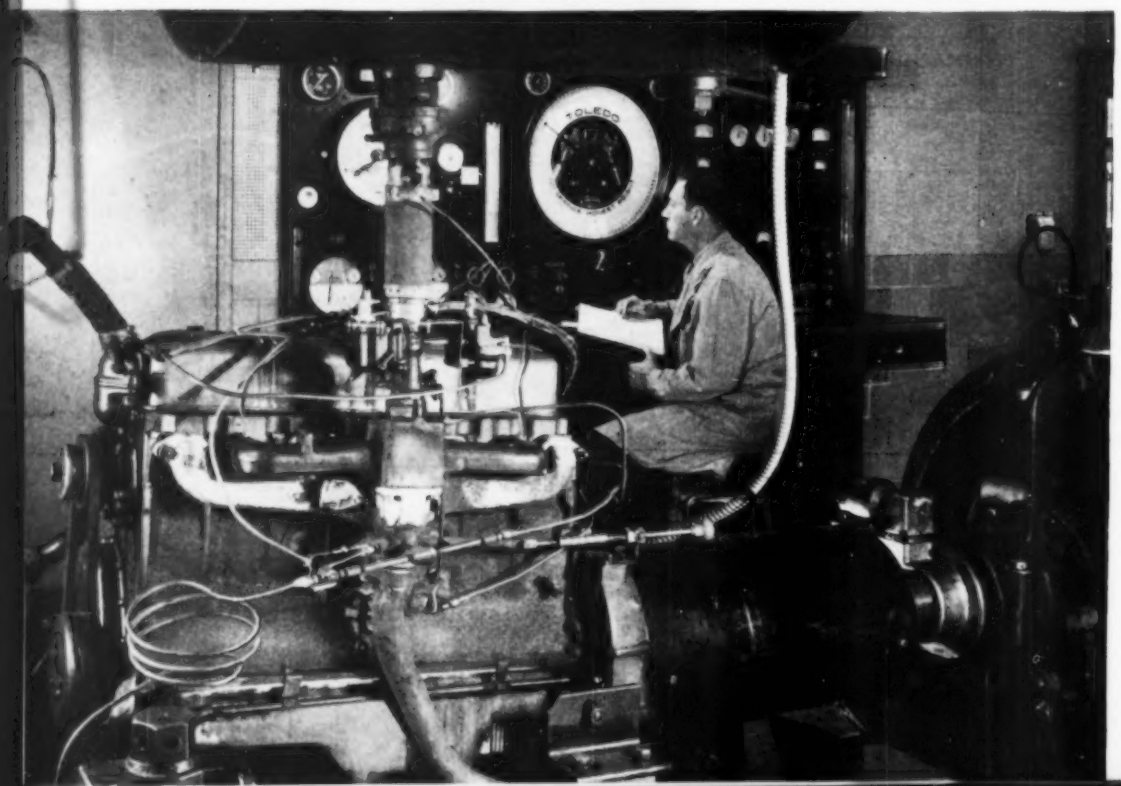


IN ORDER that fuels may be used most efficiently in automotive engines, the petroleum refiner, the automotive engineer, and the technologists responsible for antiknock fluids must work together as a team.

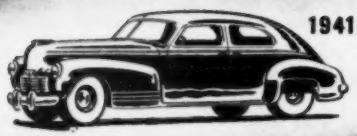
Furnishing the automotive engineer with the latest technical information on fuels and fuel trends for guidance in the design of improved engines is essential to the success of this teamwork. Much of this information comes from the more than 225 refining companies which improve their gasolines with "Ethyl" brand of antiknock compound. The Ethyl Research Laboratories, closely associated with the technical and refining departments of these companies, continuously collect and integrate information on fuels and petroleum refining.

A continuous program of study enables Ethyl's laboratory staff to interpret refining progress in terms of possible future engines. Because of the strategic location of Ethyl's modern laboratories in the center of the automotive industry, this store of technical information is available immediately for the benefit of automotive engineers.

Ethyl fuel research in standard and experimental engines assures most effective use of "Ethyl" antiknock compound.



to automotive industry

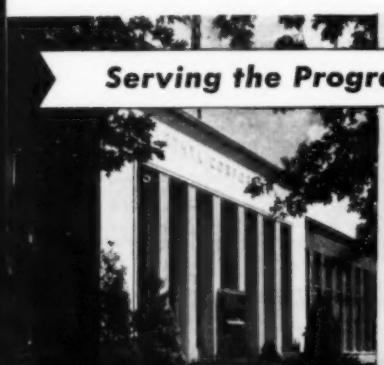


Data on fuel trends become increasingly important to automotive engineers as the relationships between engines and fuels become increasingly complex. Today the refiner is producing a larger number of components for blending base gasolines. These stocks represent many classes of hydrocarbons having a variety of molecular structures that cover a wide range of antiknock performance.

Concurrently the automotive engineer is designing more compact engines having greater economy, performance, and durability. In the continuous program of providing the most economical transportation for the motoring public, automotive engineers must understand the potentialities and limitations of the gasolines made by the latest refining processes. The Ethyl Research Laboratories maintain close contact with both the automotive and the petroleum industries, and cooperate in research programs designed to add to the knowledge of engine-fuel relationships. This kind of teamwork does much to assure that engines are designed to make the best use of the products of the oil companies.

Keeping automotive engineers informed concerning the problems and products of petroleum refiners is just one of the services provided by the Ethyl Laboratories for the benefit of the oil industry. Other messages in a series, of which this is the tenth, will discuss other phases of the complex problems faced by refiners in providing gasolines for today's and tomorrow's engines and the contribution of the Ethyl Corporation to their solution.

One of the aims of the Ethyl Research Laboratories is to present the refiners' point of view to the automotive engineer.



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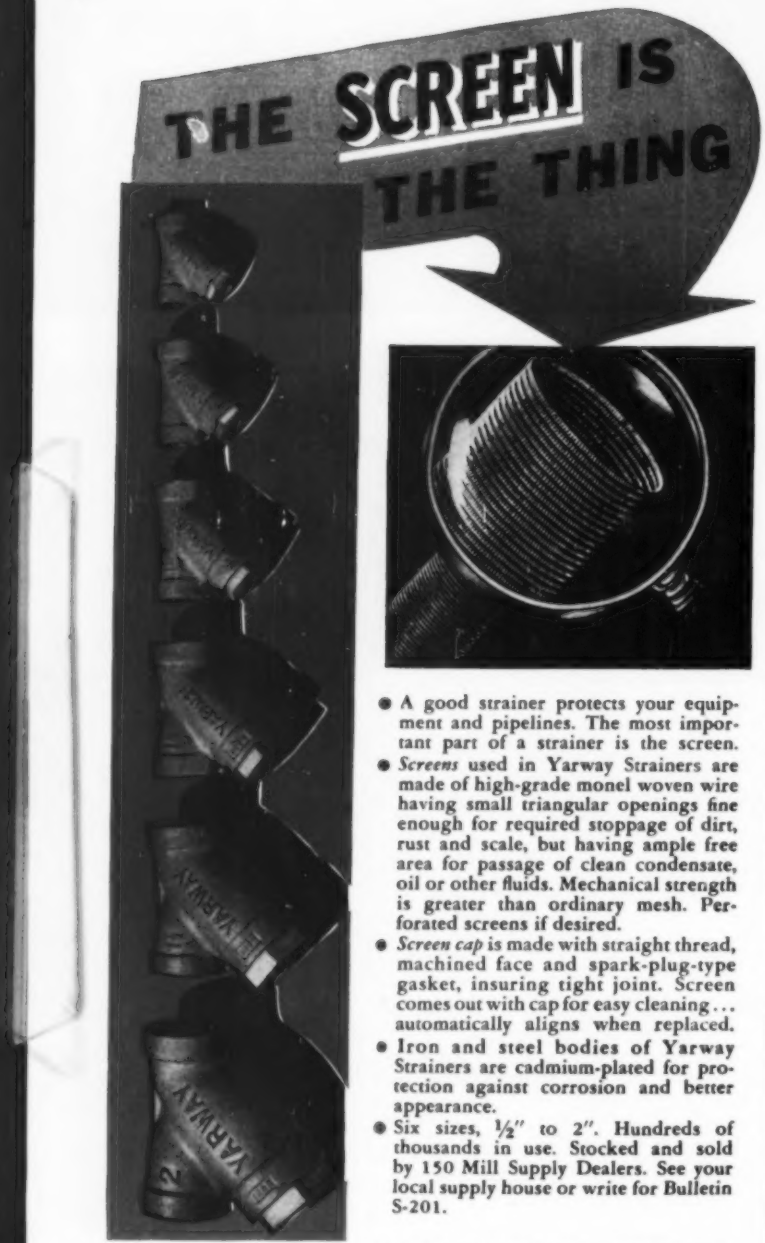

- A good strainer protects your equipment and pipelines. The most important part of a strainer is the screen.
- *Screens* used in Yarway Strainers are made of high-grade monel woven wire having small triangular openings fine enough for required stoppage of dirt, rust and scale, but having ample free area for passage of clean condensate, oil or other fluids. Mechanical strength is greater than ordinary mesh. Perforated screens if desired.
- *Screen cap* is made with straight thread, machined face and spark-plug-type gasket, insuring tight joint. Screen comes out with cap for easy cleaning... automatically aligns when replaced.
- Iron and steel bodies of Yarway Strainers are cadmium-plated for protection against corrosion and better appearance.
- Six sizes, ½" to 2". Hundreds of thousands in use. Stocked and sold by 150 Mill Supply Dealers. See your local supply house or write for Bulletin S-201.

YARNALL-WARING COMPANY
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YARWAY STRAINERS
"Police the Pipelines"

trogen or an oxide of nitrogen. This pre-treatment, which is suitably repeated intermittently, activates or reactivates the walls of the reactor and effects high yields of the desired oxygenated organic products. The process is particularly useful in the production of tertiary butyl hydroperoxide, di(tertiary butyl) peroxide and mixtures thereof from isobutane and oxygen.

U.S.P. 2,452,040. Solvent Extraction of Mercaptans. H. E. Drennan to Phillips Petroleum Company.

High boiling mercaptans are produced by catalytic addition of H_2S to an olefin polymer fraction with 10-14 C atoms. A crude mercaptan oil admixed with unreacted olefin is obtained. This mixture is subjected to extraction with an aqueous alcoholic alkali metal hydroxide solution under conditions suitable to separate mercaptans from hydrocarbons.

U.S.P. 2,452,326. Controlled Oxidation of Paraffinic Hydrocarbons. F. F. Rust and W. E. Vaughan to Shell Development Company.

A saturated aliphatic hydrocarbon with two to five C atoms is treated with oxygen in the presence of HBr at a temperature between 100° C. and that at which spontaneous combustion and decomposition of the hydrocarbon will occur. Examples are: production of methyl ethyl ketone and diacetyl from n-butane; acetone and propionic acid from propane; acetic acid from ethane.

U.S.P. 2,452,700. Copolymers of 2,5-Dimethyl-1,5-Hexadiene and Acrylic Esters. P. O. Tawney to U. S. Rubber Company.

A mixture of 2,5-dimethyl-1,5-hexadiene and an acrylic ester with a molar ratio of from 1:1 to 6:1 of diene to ester is copolymerized by heating, preferably in the presence of a peroxide catalyst. The acrylic ester employed shall be of the formula: $CH_2{=}CX{-}CO_2{-}Y$ where X is H or an alkyl radical and Y is an alkyl, aryl, or aralkyl radical. Acetone-soluble unsaturated copolymers are obtained.

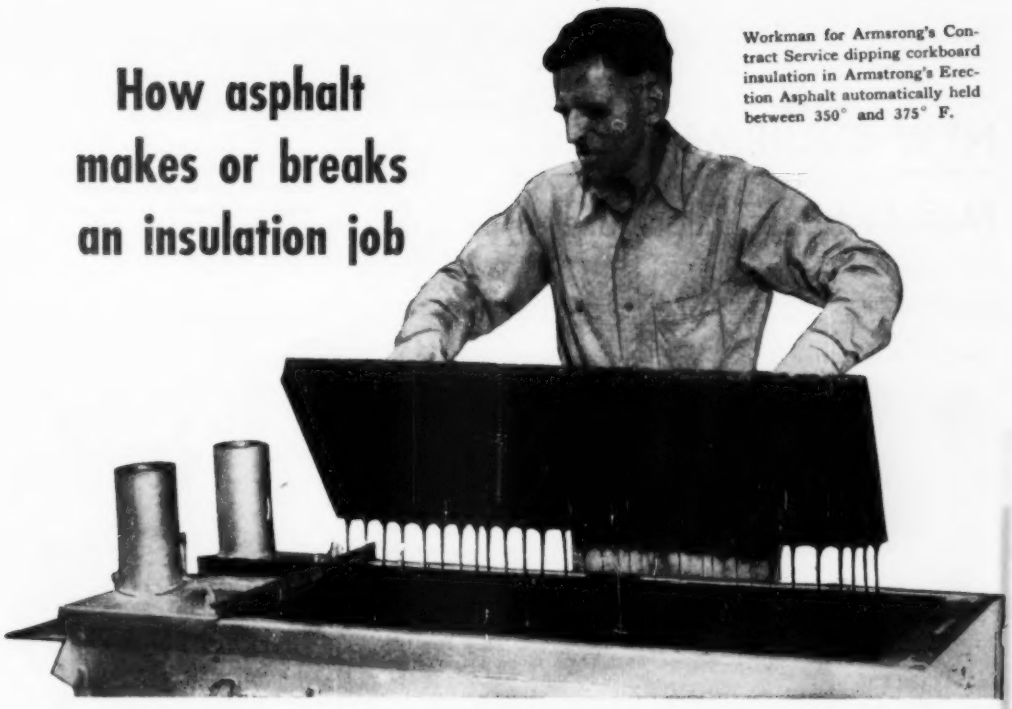
U.S.P. 2,452,741. Production of Dibasic Acids. H. W. Fleming to Phillips Petroleum Company.

A cycloparaffin, such as cyclopentane, is oxidized in liquid phase with gaseous oxygen. A mixture is formed which contains a non-aqueous phase comprising cyclic ketones and cyclic alcohols, and an aqueous phase comprising aliphatic hydroxy acids and lactones. After removal of the non-aqueous phase, the aqueous phase is further oxidized at a temperature of 50-90° C. to form the corresponding dibasic acids, such as glutaric acid and succinic acid.

U.S.P. 2,453,039. Manufacture of Resins from Sulfur Dioxide and Unsaturated Organic Compounds. A. K. Scribner and F. W. Wilder to Phillips Petroleum Company.

Olefin, preferably with at least four C atoms, is reacted with liquid SO_2. The amount of liquid SO_2 present shall be at least 15 times by weight that of the olefin charged to the reaction zone. The resulting solid resin remains dissolved in the excess of liquid SO_2 present. Details are claimed for the recovery of the resin in the form of a finely divided powder suitable for molding without mechanical grinding.

How asphalt makes or breaks an insulation job



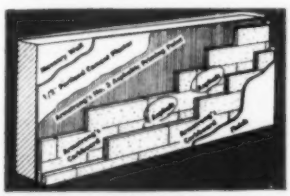
Workman for Armsrong's Contract Service dipping corkboard insulation in Armstrong's Erection Asphalt automatically held between 350° and 375° F.

THE kind of asphalt used and the way it's handled can make or break your insulation job. Asphalt does two vital things. It holds the insulation firmly in place, and it seals out air and moisture. The use of a poor asphalt, or the improper handling of asphalt on the job, can allow the insulation to loosen or the vapor seal to fail.

That's why Armstrong has devoted years of research to this phase of its insulation contract service. The kind of asphalt Armstrong workmen use, and the way they use it, add greatly to the performance of every Armstrong low-temperature job.

1. Material. Armstrong's Erection Asphalt has been developed to strict specifications. Exactly the right melting point, flash point, volatility, and solubility are assured. This odorless asphalt has been oxidized in refining to make it extra tough and chemically stable.

2. Handling. Asphalt must be heated to just the right temperature if it is to bond firmly. Armstrong workmen are equipped with thermostatically controlled tanks to hold dipping temperatures steady.



Armstrong specifications for erection of board-type insulations call for proper use of hot asphalt, a vital part of every well-applied insulation job.

3. Application. When applying insulation, Armstrong mechanics set their equipment near the work in progress to make sure the asphalt stays hot on the dipped insulation board and bonds it securely to the wall.

In mopping asphalt on floors, they cover only small areas at one time to avoid overcooling before insulation is applied.

If you plan to build or enlarge any low-temperature space, it will pay you to get full information on Armstrong's Complete Contract Service. It offers you expert engineering advice, top-quality materials, and workmen who know how to handle them properly. Write to Armstrong Cork Company, Industrial Insulation Department, 7501 Concord Street, Lancaster, Pa.

ARMSTRONG'S INDUSTRIAL INSULATION

Complete Contract Service For All Temperatures

From 300° Below Zero

To 2800° Fahrenheit

NEW EQUIPMENT

Manufacturers' Literature

For copies of manufacturers' literature or more information on products described on these pages use the number shown for each item.

Pressure Transmitter

By means of Manning, Maxwell and Moore, Inc.'s, new microsen pressure transmitter pressure motion is picked up from the tip of a bourdon tube and converted into a stable and accurate D. C. signal which can be indicated or recorded with milliampere or millivolt instruments. The electrical output is directly proportional to the movement of the bourdon tube, making it possible to use uniformly graduated scales. Either the pressure system or the electrical system may be serviced independently of each other. Standard pressure ranges up to 50,000 pounds are available. Operating voltage is 115 volts at 50-60 cycles. Normal voltage variations do not materially influence the final readings.

For a copy of Bulletin 145 describing the transmitter write Manning, Maxwell and Moore, Inc., 11 Elias Street, Bridgeport, Conn., referring to PETROLEUM REFINER item **1.**

Hard Surfacing Powder

Used for depositing a thin chromium carbide type of hard surface that is resistant to abrasive wear and corrosion, The Lincoln Electric Company's hard surfacing powder, Surfaceweld A, is to be applied with a carbon electrode. It can be used with an a.c. arc with a single carbon electrode and it may also be applied with a twin carbon arc or may be used with d.c., carbon electrode negative. The powder forms a paste when mixed with water and "it is particularly designed for thin work, thin deposits and for use with small a.c. welders." The hardness of the smooth dense deposit is approximately 54-61 Rockwell C for one layer and 57-63 for multiple layers. Hardness depends on the amount of admixture. It develops full hardness in the as-deposited condition, and maintains the hardness and resists scaling at elevated temperatures.

For further information write The Lincoln Electric Company, 12818 Coit Road, Cleveland 1, Ohio, referring to PETROLEUM REFINER item **2.**

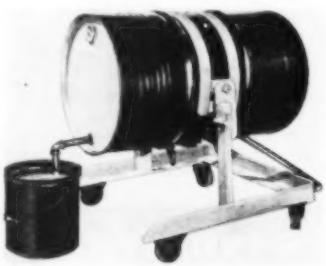
Dry Chemical Extinguisher

American-LaFrance-Foamite Corporation's new dry chemical type fire extinguisher, which has the Underwriters' Laboratories label and is rated B-1 and C-1, is recommended for flammable liquid and electrical fires. A hand portable unit, No. 30 Alfco Dry Chemical, has a longer range, longer duration of discharge, more complete discharge of the dry chemical contents, gas-tight, all-internal expelling gas connections, built-in safety disc and lighter weight. The dry chemical is nontoxic, noncorrosive, nonconductor of electricity and will not freeze.

For further information write American-LaFrance-Foamite Corporation, Elmira, N. Y., referring to PETROLEUM REFINER item **3.**

Barrel Cart

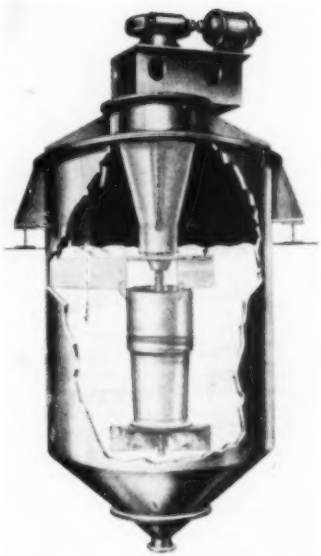
Developed for moving, pouring, emptying and mixing, Hodgson Engineering Manufacturing Company's barrel cart has a handle at the rear which locks at a convenient height for pushing or pulling and four-inch casters for easy moving. The handle raises the barrel 7½ inches from the floor and when raised, the barrel may be rotated end over end



for mixing its contents. Pouring involves no valve, pipe nipple or cap.

For further information write Hodgson Engineering Company, 1505 East 7th Street, Tulsa, referring to PETROLEUM REFINER item **4.**

Agitator



The Goldman agitator, recently patented in America by Dr. Bronislaw Goldman, Pittsburgh consulting engineer, will be furnished for chemical and other industrial plant installations by Koppers Company, Inc. The agitator propels liquid to the sides of the tank and upward. At the top, the liquid is drawn to the center where it is pulled downward through the hollow axis upon which the agitating blades are fastened. It is expelled from the bottom of the axis to repeat the process.

For further information write Koppers Company, Inc., Pittsburgh 19, referring to PETROLEUM REFINER item **5.**

Drawn Wire

Hastelloy and multimet alloy drawn wire is available in sizes down to 0.060 inches in diameter from Haynes Stellite Company. Sizes below 0.060 inches in diameter can be supplied by Kemet Laboratories Company, an affiliate of Haynes. Both alloys are used for welding, metal spraying and the manufacture of wire screen, wire cloth and springs. Hastelloy alloys have high strength and

NUMBER 1 OF A SERIES PRESENTING:

Pacific's Proved Performance

in years of uninterrupted service!

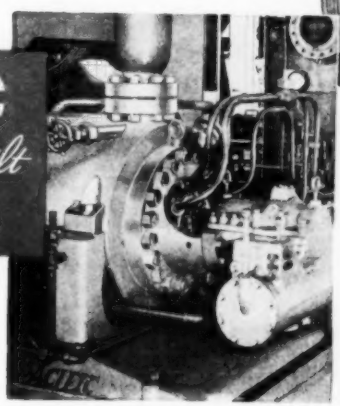
In January 1938 Wilshire Oil Company installed a 4-inch, 8-stage PACIFIC PUMP, Type ITB, Serial Number 4445. Following good practice, this pump was thoroughly inspected and checked in January 1939 and then returned to service.

Look at the Log:

From January 1939 to March 1948 this PACIFIC PUMP was on stream a total of 62,789 hours...delivered 31,000,000 bbls. of 600°F. oil against a discharge pressure of 800 p.s.i.g. THAT'S PACIFIC DEPENDABILITY!

During this same period the stuffing boxes were repacked 5 times and, in April 1946 one new shaft sleeve was installed...PACIFIC PUMP maintenance cost from January 1939 to March 1948 was only .0164¢ per 1000 lbs. of oil pumped. THAT'S PACIFIC ECONOMY!

Because this PACIFIC PUMP had not been opened for inspection during its many years of continuous service, it was deemed advisable to check the interior clearances and replace parts if necessary. The check was made during the March turn-around and the pump returned to service to continue its outstanding performance record. THAT'S PACIFIC SERVICE!



PACIFIC *Precision Built* PUMPS

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Huntington Park, California
One of the Dresser Industries
Export Office:
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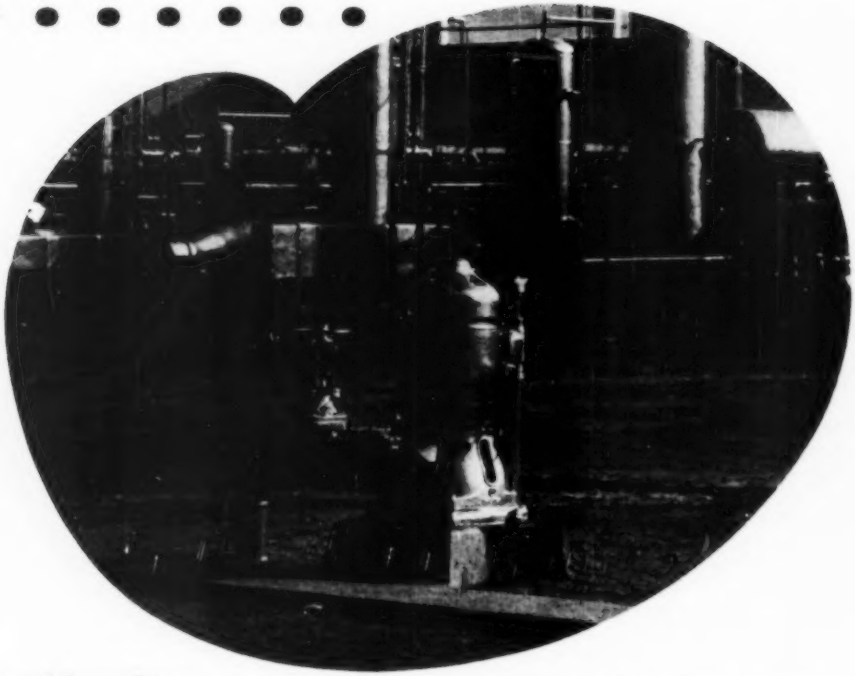
Offices in All Principal Cities

PR-4



You'll Be Needing More and More Water

—And in 1949 you are not going to do a lot of experimenting on Well Water Equipment. You and your engineers will want to insist that your Well Water Systems be built by Layne. You already know what you are going to get in a Layne. You know that they are rugged enough to stand up under the heaviest use—efficient enough to give you tremendous amounts of water at an absolute minimum of cost. And furthermore, you know that the Layne Organization can be depended on before—during—and after the installation has been made.

—Hundreds of Layne Well Water Systems are already serving refineries, pumping stations and field development activities. These fine Water Systems are in there humming along—month in and month out—seldom needing repairs of any kind and proving that they are built and installed right.

—Should your Layne installation ever need attention, you know that it will be provided promptly, thus saving expensive loss of time.

—All of these fine factors add up to exactly what you are looking for—plenty of water—low upkeep—economical operation and long life.

If you need more water—at very low cost, call or write for complete information, catalogs, bulletins, etc. No obligation. Address

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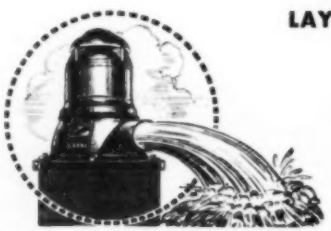
General Offices
MEMPHIS 8, TENN.



Layne Vertical Turbine Pumps are available in sizes from 40 to 16,000 gallons per minute. Write for pump catalog.

LAYNE WELL WATER SYSTEMS

AFFILIATED COMPANIES—Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Pacific, Inc., Seattle, Wash. ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City ★ Layne-Minnesota Co., Minneapolis, Minn. ★ International Water Corporation, Pittsburgh, Pa. ★ International Water Supply, Ltd., London, Ontario, Canada ★ Layne-Hispano Americana, S. A., Mexico, D. F.

a nickel base. They will withstand the action of common mineral acids and oxidizing agents. Multimet alloy is composed of cobalt, chromium, nickel and iron. Developed for use at elevated operating temperatures, the alloy is comparable in tensile properties to high-strength steels.

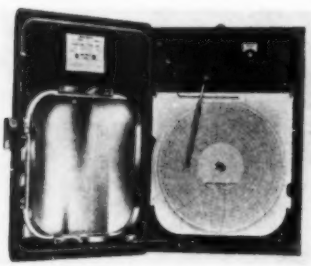
For further information write Haynes Stellite Company, Kokomo, Ind., referring to PETROLEUM REFINER item **6.**

Valve Reseating

Grace Products Company's valve reseating tool is operated with an ordinary brace or hand drill equipped with a screw-driver bit. It employs aluminum-oxide cloth-backed discs mounted on both faces of a flat steel main body. One side has a coarse abrasive disc and the other side a disc of finer grit. The discs are reversible. It is not necessary to disturb the stem packing since there is a steel disc on each face which guides the tool in the valve seat. The reseater is self-aligning and no slivers or metal chips result from the grinding operation. Sets of Pivot tools have extra abrasive discs and two special faucet reseaters operated with ordinary screw-drivers. Set 60 is for valves of ½ to 2 inches inclusive and set 80 is for valves ½ to 3 inches inclusive.

For further information write Grace Products Company, P. O. Box 2466, Birmingham, Ala., referring to PETROLEUM REFINER item **7.**

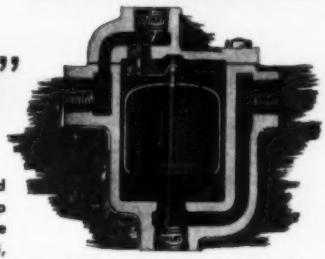
Running Count Recorder



Recording the total count of intermittent operations and the time at which each one occurs, The Bristol Company's running count recorder plots on a circular chart a curve of the number of operations against time. The total number

HERE'S A
NEW Clark Trap
TO DO YOUR DRAINAGE JOBS BETTER FOR LESS MONEY!

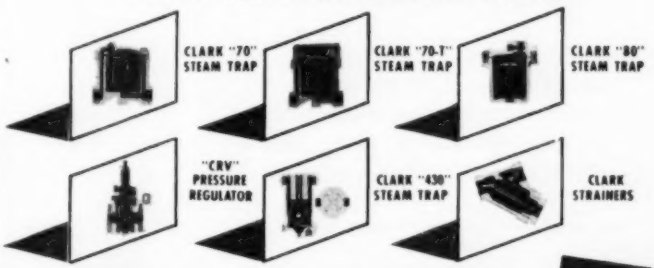
The Versatile
CLARK "60"
STEAM TRAP



The ever increasing demand for the new CLARK "60" Steam Trap proves that Clark engineers "hit the jackpot" again on this one! It is small, costs less, yet it does a better job in more places than any other trap in its class!

The CLARK "60" is "the small trap with the big trap features" such as positive seating with guided disc. It is equipped with two inlets and two outlets for easy installation on horizontal or vertical lines.

THE CLARK MANUFACTURING CO.
1847 EAST 38TH STREET • CLEVELAND 14, OHIO



Clark

Write today for complete story on Clark Traps and Valves.

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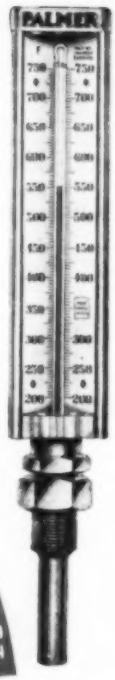
"TEMPERATURE TAKINGS" EASIER WITH PALMER...

'Round the refinery where temperatures have to be right, you can always depend on Palmer Thermometers for easier temperature taking . . . that "Red-Reading-Mercury" really stands out. The extra-wide scale space and larger markings give you pin-point accuracy. And that accuracy is *guaranteed permanently.*

With the new extruded brass case and smooth chrome finish, your Palmer Thermometers are just as good looking as they are accurate. Easy to clean, easy to KEEP clean. Always stays good-looking!



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Cincinnati 12, Ohio

CANADIAN PLANT: King & George Sts., Toronto, 2

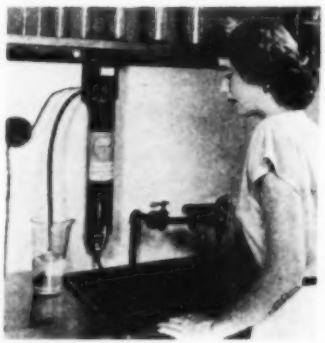
red reading mercury

PALMER THERMOMETERS INC.

of operations or pieces produced can be found by multiplying the number of complete pen transverses across the chart by the count per transverse for which the instrument is calibrated. The hourly rate of production can be read from the chart and the instrument can be used as a basis for paying production employees.

For further information write The Bristol Company, Waterbury, Conn., referring to PETROLEUM REFINER item **8.**

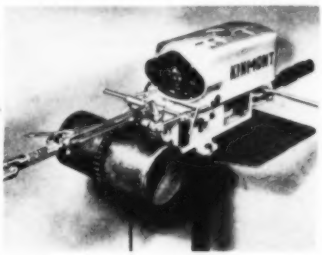
Cartridge Demineralizer



Guaranteed to contain no more than ten parts of dissolved ionized solids per million parts of water, exclusive of silica, American Cyanamid Company's redesigned Filt-R-Stil cartridge demineralizer delivers a chemical equivalent of distilled water without heat and at a maximum rate of ten gallons per hour. The rated capacity of the cartridge used is 1100 grains (as $CaCO_3$), but the quantity of water treated per cartridge depends on the quality of the raw water. The conductivity indicator shows the quality of treated water continuously. Previously it had been necessary to check the conductivity at various intervals.

For further information write American Cyanamid Company, 30 Rockefeller Plaza, New York 20, referring to PETROLEUM REFINER item **9.**

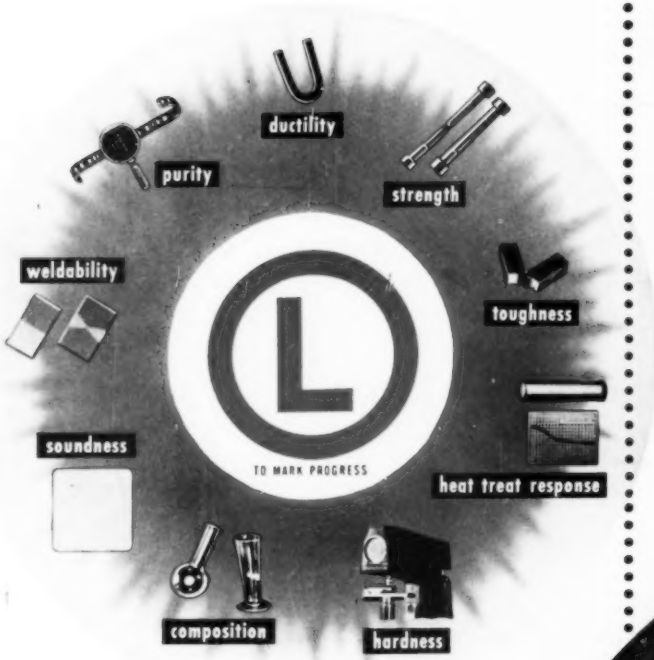
Cutting Torch



Kinmont Manufacturing Company, Inc.'s new cutting torch attachment for the Kinmont universal power unit can be used on pipe sizes from 3 to 36 inches in diameter. Tanks up to 10 feet in diameter may also use this accessory when they are turned on a roller rack. The turning speed is controllable while cutting is in progress by means of a

Controlled Quality

assures metal soundness



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Each Ladish fitting has the chemical composition and physical properties essential for long, trouble-free operation under recommended service conditions. Laboratory test reports . . . pioneered by Ladish . . . provide an extra assurance of metallurgical soundness essential for dependable performance.

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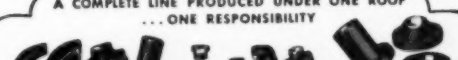
. . . ONE RESPONSIBILITY



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Indiana Farm Bureau Co-op Ass'n.
Interlake Chemical Corporation
Leonard Refineries, Inc.
Mercury Oil & Refining Company
Midland Cooperative Wholesale
Midwest Refineries, Inc.
Naph-Sol Refining Company
National Refining Company
Natural Gas Pipeline Company of America
Northwestern Refining Company
Petroleum Equipment Company
Petroleum Specialities, Inc.
Producers Refining Company
Stanolind Oil & Gas Company
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Vickers Petroleum Company
Waggoner Estate Refinery
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Treco is pleased to have been chosen to handle the design, engineering and construction of the combination 5,000 barrel topping-vacuum-vis-breaking unit for the Empire State Oil Company of Thermopolis, Wyoming. This unit will process 5,000 barrels per day of Wyoming, Hamilton Dome crude, the major portion of which is produced by the Empire State Oil Company. The company will make tractor distillate, burning oils, road oils, fuel oils and various asphalt products. The Wyoming, Hamilton Dome crude is a heavy, high sulphur type which lends itself to the production of high-quality asphalt products.

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The REFINERY ENGINEERING Co.

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foot switch. This leaves the operator's hands free. A patented split-link chain drive permits rapid fastening and unfastening of the work being done. The drive chain holds the pipe locked in position, turning against fixed rollers on the power unit. According to the manufacturer this prevents creeping of the work and enables the attachment-held cutting torch to produce a smooth, accurately beveled and square pipe end.

For further information write Kinmont Manufacturing Company, Inc., 716-718 West Wilson Avenue, Glendale 3, Calif., referring to PETROLEUM REFINER item **10.**

Fork-Lift Truck

Clark Equipment Company's Elec-Clipper-2024 is equipped with a 124-inch lift (less forks), solid tires and the company's new squeezer up-ender. This device handles barrels in a manner entirely new in the fork-lift truck field. The machine features a new design which reduces the turning radius of the model, the company claims.

For further information write Clark Equipment Company, Battle Creek, Mich., referring to PETROLEUM REFINER item **11.**

Line Strainer

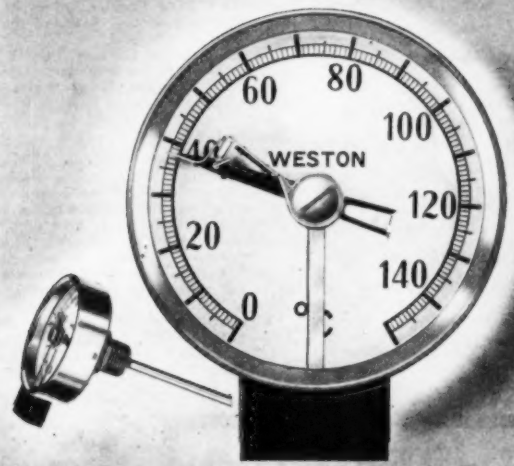
Milwaukee Valve Company's lightweight line strainer is made of milvaloy and is 55 percent lighter than bronze or

NEW—

all-metal WESTON

Contact-making

thermometer



This new Weston combines the features of an indicating device with the advantages of an alarm or control instrument. A contact arm, mounted as shown above, is easily set to make contact at any temperature on the scale.

A terminal block on the periphery of the case makes electrical connection easy. The thermometer is all-metal, typically WESTON in ruggedness and reliability, with accuracy of ±1% as an indicating thermometer, and ±1½% as a contact making device. It is supplied in two types—for operation on either increasing or decreasing temperatures.

For complete information see your local WESTON representative or write Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey.

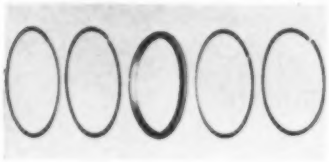
WESTON

Thermometers

iron strainers of the same size. Available in sizes from one to four inches, the strainer has a special yoke design which permits easy removal of the strainer for cleaning.

For further information write Milwaukee Valve Company, Milwaukee, Wis., referring to PETROLEUM REFINER item **12.**

Ring Packing



Piston Assembly

Rod Assembly

Consisting of a resilient sealing ring of synthetic rubber in a T-section backed up or supported on each side by two non-extrusion ring retainers or guards, Greene, Tweed and Company's Palmetto G-T ring packing may be used in systems where the temperature range is from —70° to 250° F. and will not leak or fail over extended periods of operation with pressures anywhere from 0 to 3000 psi. Actual tests have been run at 10,000 psi. When the operating pressure is increased, the flange of the G-T ring expands radially against the non-extrusion rings, holding them in contact with the surface of the cylinder or piston rod. This action prevents the sealing surface from being damaged by extrusion into the clearance space between the mating parts, according to the manufacturer. Diametric variations and finishes of piston grooves of the packing do not require close control because the rings help remove the foreign matter from the surface of the rod type packing. Palmetto G-T Ring Packing comes in the external or piston type seal and the internal or rod type seal.

For a copy of Bulletin TB-918 describing the ring packing write Greene, Tweed and Company, North Wales, Pa., referring to PETROLEUM REFINER item **13.**

Electrodes

Arcos Corporation's Monend 806 electrodes produce X-ray quality welds on monel, monel clad and steel, eliminating the necessity of depositing a buffer layer of nickel. With its spray type arch, all-position welding is facilitated. Elongation value is normally 50 percent or higher. Typical weld metal yield strength is 42,500 psi and tensile strength is 75,500 psi.

For further information write Arcos Corporation, 1500 South 50th Street, Philadelphia 43, referring to PETROLEUM REFINER item **14.**

Micro-Feeder

Designed to inject a smooth, uninterrupted flow through a capillary tube and injection needle, %Proportioneers, Inc.%'s micro-feeder is a new precision machine for laboratory operations such as the injection of additives into pressure autoclaves. Capacity of the standard unit is 100 cc., with feeding rates as low as 1 cc. per hour. Either change gears or variable speed drives are available to provide constant rate of flow proportional feeding. A synchronous 110-volt a.c. motor is automatically stopped

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Here's all you need do: Pump-circulate a recommended solution of Oakite Compound No. 32. When descaling is complete, rinse and neutralize with an Oakite alkaline solution. You'll find Oakite descaling time-saving and safe. Why not talk it over with the Oakite Technical Service Representative near you. Or write direct for complete, free data. Oakite Products Inc., 50B Thames St., N. Y. 6, N. Y.

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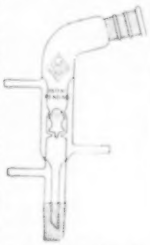
when the limit of the plunger travel is reached. A signal light and four-figure totalizer are also included. Accuracy "is assured with the 100 percent volumetric efficiency of the instrument."

For further information write %Proportioneers, Inc.%, 31 Codding Street, Providence, R. I., referring to PETROLEUM REFINER item **15.**

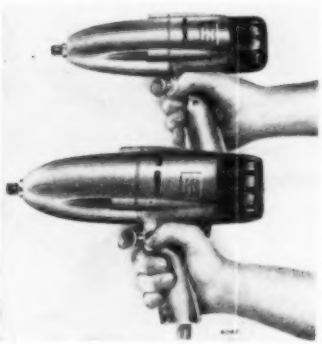
Vacuum Adapter

Scientific Glass Apparatus Company, Inc.'s new glass Theimer vacuum adapter is applicable to all types of fractionating, including distillation of medium boiling liquids under poor vacuum and high vacuum distillation of low volatile oils. Under all conditions, "the operation is leakproof." The adapter contains no stopcocks, but employs an internal glass valve automatically lubricated by the distilling liquid. All manipulation is in a three-way stopcock in the pump system, removed from contact with the distillate. It does not require cleaning after each distillation. One model of the instrument has a jacket around the valve and is used for circulation of coolant when distilling limpid materials or of warm liquid with viscous materials. A second model without a jacket is for normal distillates.



For further information write Scientific Glass Apparatus Company, Inc., Bloomfield, N. J., referring to PETROLEUM REFINER item **16.**

Electric Impact Tool



Model 8U, Ingersoll-Rand Company's larger and heavier electric impact tool, has all the features and advantages of the smaller 4U models. The tool, with standard accessories, will run and remove nuts up to ⅝-inch thread size, drive and remove studs, extract broken cap screws and studs, apply and remove machine screws of all kinds, run wire brushes, drill brick, metal and masonry, tap and ream. It may be used for woodboring also. The reversible motor makes it as easy to remove screws, studs and nuts as to apply them. Motor burn-out is eliminated, even if the spindle stalls

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THOROUGH coverage of current technical and economic thought in the field of petroleum refining, natural gasoline and petrochemical manufacturing.

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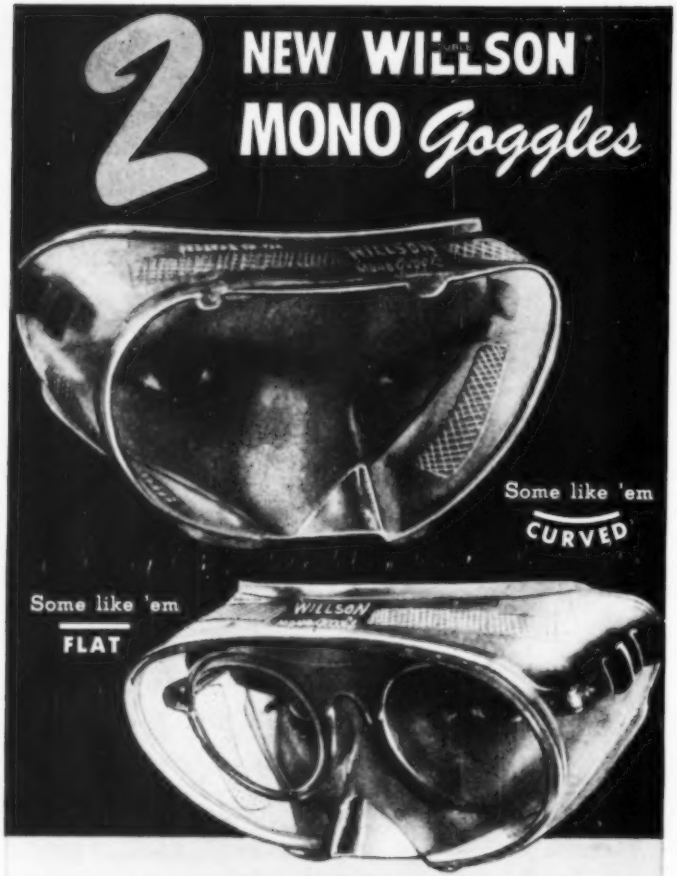


Newly styled plastic eye protection with choice of curved or flat lenses offer new features designed to add to their already predominant popularity. The WILLSON MONOGOGGLE, just over an ounce in weight, is the answer to getting safety equipment worn on many hazardous jobs.

- The new flat lens design retains all the safety features of the curved lens.
- Both provide ample room for wearing of prescription glasses in comfort. The flat style, however, provides additional clearance for molded spectacle frames.
- New drop-eye shape gives wider vision.
- Greater ventilation area provides better air circulation and more wearer comfort.
- Both new designs available in clear acetate frames or the new flexible, mottled-brown, polythene frame.

WILLSON*

For complete information on these products and their application, as well as other eye and respiratory protective devices, get in touch with your Willson distributor or write us direct.

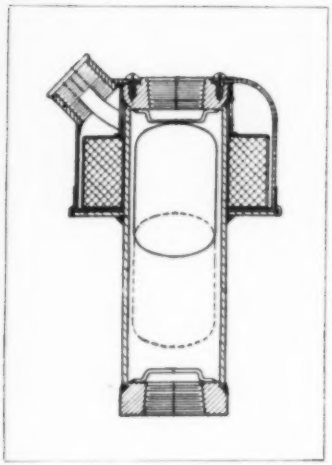
*T. M. Reg. U. S. Pat. Off.

WILLSON PRODUCTS, INC., 105 THORN STREET, READING, PA.

completely. The impact principle operates whenever resistance is met, and virtually no torque reaction is transmitted to the operator under any condition.

For further information write Ingersoll-Rand Company, 11 Broadway, N.Y., or any branch office or distributor, referring to PETROLEUM REFINER item **17.**

Automatic Control Switch



Clapp Instrument Company's new automatic liquid level control switch, Acrafloat, is operated by a free buoyant float, encased in a vertical metal pipe. It controls and indicates liquid levels to a fraction of an inch. Especially suitable for applications involving unusual conditions, such as high temperature, high pressure, corrosive or non-conducting liquids, the Acrafloat may be used to operate pump motors, valves or indicating lights.

For a copy of a booklet giving details and diagrams of its construction and operation, write Clapp Instrument Company, Department A, Webster, Mass., referring to PETROLEUM REFINER item **18.**

Safety Helmet

Industrial Products Company's "Turtle-Back" safety helmet is made of a multiple layer of cloth impregnated bakelite, molded under pressure of 250 pounds at 300 degrees temperature. It produces a tough, shock-resisting shell with light-

ness of weight. The liner is attached so that the weight is evenly distributed. The lace is of nylon and provides long service life and offers resistance when used near acid fumes. A leather sweatband may be adjusted to fit all head sizes. Air space is at the sides and top of the head in the liner. The helmet has an impact strength of 80 foot pounds and can withstand 2000 volts A. C. with less than three milliamperes when completely immersed in water.

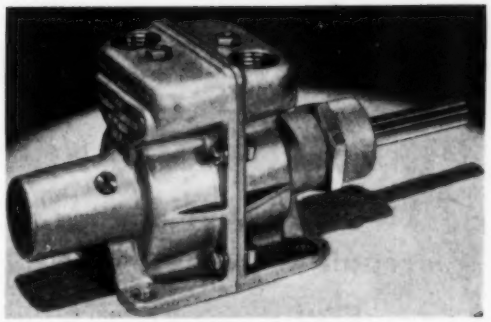
For further information write Industrial Products Company, 3030 North Fourth Street, Philadelphia 33, referring to PETROLEUM REFINER item **19.**

Pulmonary Apparatus

Treatment of pulmonary disorders resulting from exposure to certain chemicals, gases or superheated air in industrial processes is possible with Mine Safety Appliances Company's new pulmonary machine, "M. S. A. Pneophore." The instrument differs from a resuscitator in that it administers oxygen with intermittent positive pressure only. Suction which might damage lung tissues or other parts of the respiratory system is eliminated. The device will follow the person's natural breathing pattern, but, if the breathing has been arrested, the valve operates on a regular cycle, interrupting oxygen flow automatically when the predetermined pressure is reached. Exhalation is by passive recoil.

For further information write Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh, referring to PETROLEUM REFINER item **20.**

Gearless Pump



Eco Engineering Company's gearless pump has a new dual eccentric piston design which gives a strong flow against pressure. Available in four sizes, ¼, ⅜, ½ and ¾ inches, the pump has a capacity ranging from 1-12 gpm. The pumps can be used against pressures up to 100 psi. and will run and deliver at speeds from 200 to 2400 rpm. Fitted with self-lubricating bearings, the pump eliminates problems of lubrication and gives freedom from pump greases or oil fouling intake or discharge lines.

For further information write Eco Engineering Company, 12 New York Avenue, Newark 1, N. J., referring to PETROLEUM REFINER item **21.**

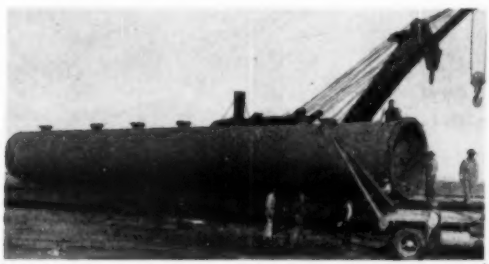
Gas Welding Rod

With Arcos Corporation's Silbrax, the company's new internally fluxed gas welding rod for welding deoxidized copper, "repeated rod oxidation and faulty weld metal can be prevented." Heat is applied first to the metal and then transmitted to the flux, forming a balance. Silbrax can be used also as a filler rod for carbon and inert arc welding.

For further information write Arcos Corporation, 1500 South 50th Street, Philadelphia 43, referring to PETROLEUM REFINER item **22.**

Aluminum Jacketing

An aluminum jacketing, said to be the first scientifically designed metal jacketing for the protection of insulated piping, has been developed by Childers Manufacturing Company. Made from .0055 inch thick full-hard (2S) aluminum, with 3/16 inch corrugations for extra strength, the jacketing comes complete with moisture barrier attached. Especially intended for the many applications where bare metal jacketing is not suitable (such as over 85 percent magnesia insulating materials) because of corrosion problems, the jacket moisture bar-



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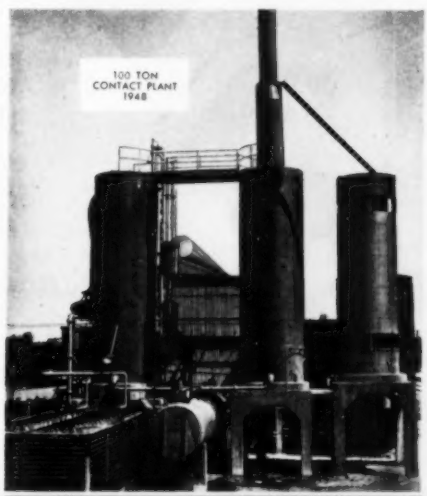
ABSORBER

102" IN DIAMETER

Built by the Superior plant for a West Texas gasoline installation. This absorber is factual evidence of the ability of all Superior departments to work as a team in producing YOUR job. The engineering department prepares the specifications; the drafting department prepares the plans and blueprints and, finally the production department delivers the finished job AS PLANNED AND AS SPECIFIED. Try us on your next job!

SUPERIOR MANUFACTURING COMPANY
AMARILLO, TEXAS



CONTACT
SULPHURIC ACID
ACID-RECOVERY
PLANTS and
DESIGNS

NICOLAY TITLESTAD
CORPORATION
11 West 42nd St., New York 18, N. Y.

Guaranteed

PIPE WRENCH ECONOMY

No pipe wrench housing repair or expense with

RIDGID

Attractive new RED Finish!

● The famous RIDGID guarantee is just one of the features that make RIDGID the outstanding favorite of millions. You also like the free-spinning adjusting nut, handy pipe scale on the hookjaw, the comfort-grip I-beam handle with flared end that keeps your hand from slipping off. For real efficiency and guaranteed economy, buy RIDGID wrenches, 6" to 60," at your Supply House.

RIDGID

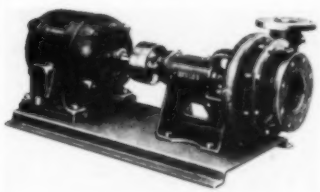
WORK-SAVER PIPE TOOLS

THE RIDGE TOOL CO. • ELYRIA, OHIO

rier has a base of 70-pound kraft paper, impregnated with asphaltic compounds, and then coated, both faces, with a sealing mixture of gilsonite, resins, waxes, and special asphalts. Advantages cited include lightness, ease of handling and erection, lower initial and application cost, low maintenance cost, and high salvage possibilities when lines are moved. Joints can be fastened directly with screws, without additional fittings. The jacketing is available in rolls, 4 feet wide by 100 feet long. Each roll, weighing about 63 pounds, is individually wrapped in corrugated cartons.

For further information, write Childers Manufacturing Company, 625 Yale Street, Houston 7, Texas, referring to PETROLEUM REFINER item **23.**

Centrifugal Pumps

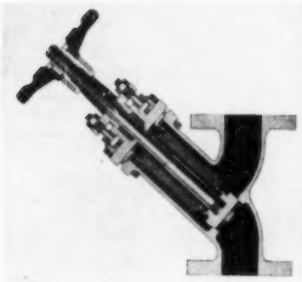


A new centrifugal pump by Goulds Pumps, Inc., is designed to pump clear liquids, general water supply, circulating, transfer service, air conditioning, irrigation and similar uses. It is available in 14 sizes for both motor and belt drives. Capacities are from 10 to 1800 gpm with heads to 120 feet.

For a copy of Bulletin 622-A-2, giving complete details on the pump, write Goulds Pumps, Inc., Seneca Falls, N. Y., referring to PETROLEUM REFINER item **24.**

Bellows-Sealed Valve Stems

Cook Electric Company has announced development of a standard series of corrosion resistant metal bellows of all-welded construction which seal valve stems against any and all corrosive agents. Packless bellow-sealed valves of nickel, monel, stainless steel, inconel and other corrosion resistant alloys give extended protection from leakage traceable to corroded seats, stems and packing, according to the manufacturer. The welded, leak-proof bellows completely surrounds that lower part of the valve stem which is within the valve body. It is welded at its lower end to the top of a disc and at the top end, to a collar which fits into the body neck. The manufacturer claims that this offers an effective seal against the entrance of any medium corrosive into the stem chamber. The bellows itself consists of corro-



sion resistant, formed metal diaphragms welded alternately at their inner and outer circumferences. They are tested to the individual valve manufacturer's specifications. Sizes range from ¼ to 12 inches.

For further information write Cook Electric Company, 2700 Southport Avenue, Chicago 14, referring to PETROLEUM REFINER item **25.**

Electrode Steam Generators

Recently Livingstone Engineering Company displayed for the first time in series 512-1½ boilers, the latest addition to the Speedylectric line of electrode steam generators. Available in three pressure ranges: series 512-100 psig, 612-200 psig, and 712-250 psig, the boiler operates on 220 volts, single phase power, measures only 14 x 21 x 35 inches and weighs less than 100 pounds. It generates sufficient steam (45 pounds per hour) to serve a heavy duty compression molding press for manufacturing plastic articles. Other applications include heating of rubber rolls and laboratory presses and autoclaves where the design gives precise regulation of critical processing temperatures. The boiler has no coils to burn out, no tubes to scale, no open flame or fire hazard and no low water danger. Heat is generated by the resistance of the boiler water to the flow of current between solid metal electrodes. If there is no water in the boiler, no current flows and the power input stops. Built to ASME code, the boilers are inspected and stamped by the National Board of Pressure Vessel Inspectors.

For further information write Living-

DURA PLASTIC
Packings

USERS everywhere are testifying to the outstanding service performed by this general purpose semi-metallic packing. DURA PLASTIC provides improved sealing for gasoline — water — air — steam — oils and chemicals . . .

★ No "breaking" when formed around shafts
★ Remains uniform in shape under compression
★ Retains resiliency throughout life of its use
★ Lubricated metallic shreds reduce frictional wear

Write Today for Your Copy Of File No. DPPR . . .
describing types and styles of metallic and semi-metallic packings to meet your specific need.

The PERFECT SEAL
DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN
MANUFACTURERS OF METALLIC and SEMI-METALLIC PACKINGS
ROTARY MECHANICAL SEALS and PACKING TOOLS

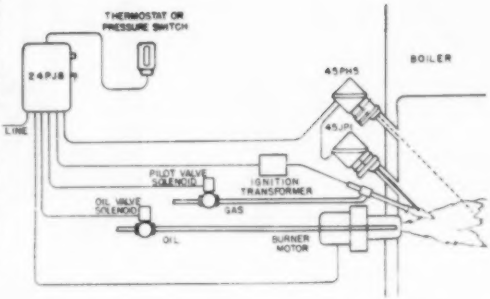
stone Engineering Company, 100 Grove Street, Worcester, 5, Mass., referring to PETROLEUM REFINER item **26.**

Combination Starter

For use in Class I, Group D hazardous locations, The Electric Controller and Manufacturer Company's new combination starter has a self-contained disconnect switch. To be used on squirrel-cage, synchronous and wound-rotor motors for 2300-4600 volt service, the Valimitor starter has an oil disconnect switch which permits isolation of the starter from the power lines. The contactor is mounted in the rear oil tank. In the front compartment is mounted the overload relay panel which gives inverse time element protection for prolonged overloads and trips instantly on short circuits. According to the manufacturer, a fault current in the motor circuit is limited to 25,000 KVA, regardless of the available KVA of the power system. There is nothing to replace after a short occurs, because the manufacturer claims that only the start button is necessary to re-start the motor. Built for motors up to 600 hp at 2300 volts and 4600 volts, 60 cycle service, the maximum rating for 25 cycle power circuits is 300 hp at 2300 volts and 250 hp at 4600 volts.

For further information write The Electric Controller and Manufacturer

Flame Failure Safeguard



Combustion Control Corporation's system for supervising both the pilot gas flame and the main oil flame of automatic oil burners gives complete protection against the hazard of explosion caused by flame failure in industrial oil burner installations. If the flame is not properly ignited, electronic flame rod type 45JP1 signals to the programming control and the burner shuts down before the main valve opens. When properly ignited, the main oil valve opening the oil flame is monitored by scanner type 45PH5, which contains both the phototube and amplifier tube, requiring no special shielded cable. The system "will withstand conditions of relatively high ambient temperature and is impervious to ambient humidity." Programming control type 24PJ8 provides accurate setting of both oil valve delay and post ignition periods. Timing is through a synchronous motor.

For a copy of Bulletin Ch4753 write Combustion Control Corporation, 77 Broadway, Cambridge 42, Mass., referring to PETROLEUM REFINER item **27.**

Specify

G-B FILTERS

for

SOLVENT DEWAXING

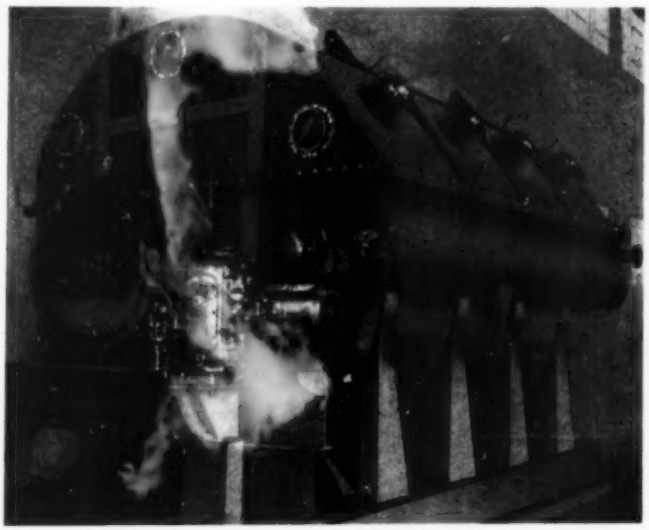
G-B pioneered the application of continuous vacuum filtration to solvent oil dewaxing. The patented G-B compartment drainage eliminates any welding or soldering of the cloth supporting members. This smooth filter cloth support with precisely machined caulking grooves assures

Maximum Filter Cloth Life.
Ease of Filter Cloth Replacement.

G-B still pioneers design improvements giving you

Lower Installed Cost.
Lower Maintenance Cost.
Greater Time on Stream.

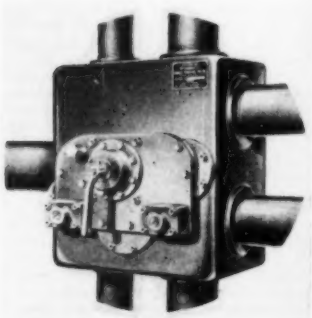
G-B dependability includes "on time delivery" at the plant site.



GOSLIN-BIRMINGHAM
MANUFACTURING CO., INC.
Birmingham, Alabama
NEW YORK: 350 Madison Ave., New York 17, N. Y.

Company, 2700 East 79th Street, Cleveland 4, Ohio, referring to PETROLEUM REFINER item **28.**

Single Control Valve



Cochrane Corporation has made its hydromatic single control valve standard equipment on the company's line of zeolite softeners and pressure filters. Control of backwash, rinse, service and chemical feed is simplified. The valve is actually a six-position valve, with four normal operating positions and two standby positions. It is suited to manual or automatic control. Power for operation is provided by the raw water. Gradual opening and closing of the valve members eliminates hydraulic shock with its attendant disruption of the bed within the container. Flexible bellows valve members control the various functions.

For further information write Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia 32, and in Canada, Canadian General Electric Company, Ltd., 212 King Street West, Toronto 1, Ontario, referring to PETROLEUM REFINER item **29.**

Switchgear and Control Devices

Described and illustrated in Allis-Chalmers Manufacturing Company's Bulletin 25B7095 is the company's line of switchgear and control devices. Types and ratings are supplied on the various equipment while standard wiring diagrams and photographs of typical station combinations accompany the data on push button stations.

For a copy of the bulletin write Allis-Chalmers Manufacturing Company, 1126 South 70th Street, Milwaukee, Wis., referring to PETROLEUM REFINER item **30.**

Pressure-Seal Bonnet Valves

Edward Valves, Inc.'s types of cast steel pressure-sealed bonnet valves are described in Catalog Section 12-H. Of new flow design, in stop, non-return and check types, the valves have chromium-molybdenum steel bodies and welding ends for services of 900, 1500 and 2500 pounds sp at 1000° F. A new method for correlation of valve size and pressure drop is also included.

For a copy write Edward Valves, Inc., East Chicago, Ind, referring to PETROLEUM REFINER item **31.**

Tubular Heat Exchangers

In The Griscom-Russell Company's Bulletin 916 shells, tube bundles, stationary heads and floating heads are explained and particular services suitable

DURALOY

Where the Oil Industry Gets Its GOOD Tube Supports

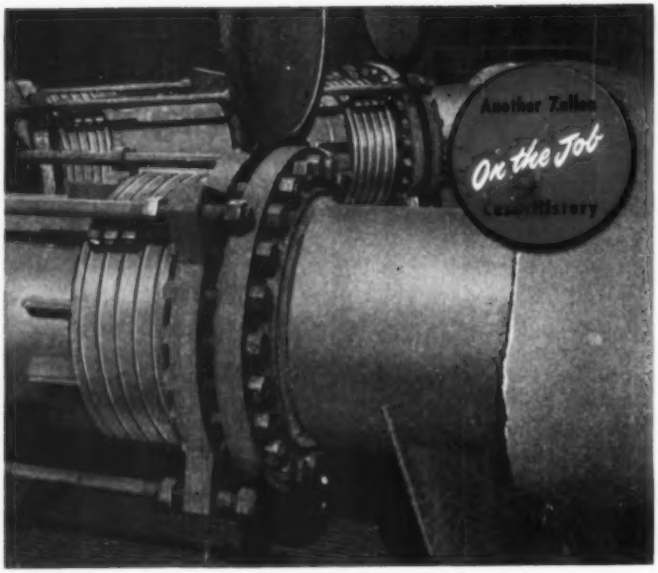
For years, we have been supplying tube supports to many refineries . . . alloyed to meet each refinery's corrosion and heat-resisting requirements . . . melted and cast by experienced high-alloy foundrymen.

To serve you — if you, too, would prefer to have Duraloy cast tube supports — we offer the most modern and best equipped exclusively high alloy foundry in the field.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • Eastern Office: 32 East 41st Street, New York 17, N. Y.

Los Angeles & San Francisco: KILSBY & HARMON — Detroit: P. F. CONNELL & ASSOCIATES



Where Dependability is a "Must"

BIG refinery operation requires only the best equipment . . . for assurance of dependable, long-lasting service. That's why Zallea Expansion Joints were the logical choice for installation in the vacuum flasher at the Shell Oil Company Refinery at Wood River, Illinois. Shown above are 24" Zallea Universal self-equalizing stainless steel expansion joints used in the transfer lines. These joints absorb 6" axial, 2" lateral movement horizontally and 1½" lateral movement vertically, and carry a mixture of hydro-carbon liquid and vapor flowing at 800° F. The entire vacuum flasher installation also includes 48" Zallea stainless steel joints in the vapor lines and 8" Zallea stainless steel joints in the bottoms line.

It's the high quality built into every Zallea Expansion Joint that makes them long-lasting—even under the severest service. Remember, there is *no* packing to deteriorate . . . *no* maintenance required. There's a Zallea Expansion Joint for almost every requirement. Available in diameters from 3" to 72" for temperatures from sub-zero to 1600° F. . . . for pressures from vacuum to 300 psi in standard designs and up to 1000 psi in special designs. Write today for your copy of Catalog 47. Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

Zallea
EXPANSION JOINTS

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS EXCLUSIVELY

for each type are given. Included also are photographs and drawings of complete units and details of design as well as modern installations of the units. Tables of the characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, the specific gravity and pounds per gallon corresponding to degrees Baume and degrees API, and a chart of the specific heats of midcontinent crude oils and the charts for solving the MTD formula with correction factors for other than counter-current conditions are shown.

For a copy write The Griscom-Russell Company, 285 Madison Avenue, New York 17, referring to PETROLEUM REFINER item **32.**

Centrifugal Casting

The Centri Die process of centrifugal casting in permanent molds is described in a Lebanon Steel Foundry bulletin. Typical cross-sections through blanks cast by the process are illustrated. Other reproductions of actual castings indicate the variety of cast rings and cylindrical structures possible to obtain, and provide examples of the variations in diameter and metal section which can be produced for a wide range of industrial applications. Emphasis is placed on uniformity of metal structure, metal conservation, production economies, finishing procedures and inspection methods under the process. Advantages claimed as inherent in the process are higher quality castings of greater density, readily achieved production of assorted parts and complex structural shapes which can not be satisfactorily cast by static methods, uniformity of casting strength through the use of alloys difficult or impossible to forge.

For a copy of the bulletin write Lebanon Steel Foundry, Lebanon, Pa., referring to PETROLEUM REFINER item **33.**

Instrument Selection

Taylor Instrument Companies has available a revised edition of Bulletin 98170, "Taylor Guide for Correct Instrument Selection," which gives a bird's-eye view of the companies entire industrial instrument line, the field of application of each type of instrument as well as its principle of operation and range limits." The basic types of instruments are discussed and then succeeding sections divide the instruments according to the variables to be measured or controlled, such as temperature, humidity, pressure, flow, liquid level, force and time cycle. Special function instruments also are described. Diaphragm valves, lever motors and precision valve positioning units are included as well as mercury-in-glass thermometers for use on industrial apparatus and intermittent testing, etched-stem thermometers and hydrometers for laboratories and general industrial use and information on Co-ordinated Control Systems.

For a copy of the bulletin write Taylor Instrument Companies, Rochester 1, N. Y., referring to PETROLEUM REFINER item **34.**

Water Treatment

In Liquid Conditioning Corporation's brochure the background, facilities, processes and equipment offered by the company in water treating and conditioning of other liquids are outlined. Installations of types of Liquon equipment are pictured and there are references to 50

technical articles covering developments in these fields.

For a copy write to Liquid Conditioning Corporation, 114 East Price Street, Linden, N. J., referring to PETROLEUM REFINER item **35.**

Silicone Fluids

The properties and behavior of Dow Corning Corporation's DC 200 silicone fluids are described in the company's new booklet. These semi-inorganic fluids have heat stability, shear resistance, relativeyl constant viscosity over a wide temperature range, lubricity, water repellency and good dielectric properties. The silicon fluid is useful as a damping and hydraulic media, as liquid dielectrics, as special purpose lubricants or as additives, impregnants or coatings. Photographs, tables, graphs and illustrative material are given.

For a copy of the booklet write Dow Corning Corporation, Midland, Mich., referring to PETROLEUM REFINER item **36.**

Corrosion-Resistant Concrete

Universal Atlas Cement Company's new booklet brings up to date late developments on Lumnite, its corrosion-resistant concrete. It describes the methods and materials used in placing Lumnite in industrial applications. Typical uses are listed and frequent questions asked about it are answered. In addition to floor applications, Lumnite is using in lining stacks, oil refinery vessels and drainage systems.

For a copy of the booklet write Universal Atlas Cement Company, Lumnite Division, 135 East 42nd Street, New York 17, referring to PETROLEUM REFINER item **37.**

Surfacing Material

The Dampney Company of America's Bulletin 1530 describes Apexior No. 1, a protective surfacing material for boilers and for power and processing equipment in wet-heat service. Application data as well as information on special Dampney equipment for the internal coating of boiler, water-wall and economizer tubes is included.

For a copy of th bulletin write The Dampney Company of America, Hyde Park, Boston 36, referring to PETROLEUM REFINER item **38.**

Relief Valves

Marine and Industrial Products Company's Catalog 80 presents its complete line of safety relief valves, giving the service, service range, special construction and specifications. Photographs, cutaway drawings and dimensions for each valve are also given.

For a copy of the catalog, write Marine and Industrial Products Company, 1524 Vine Street, Philadelphia 2, referring to PETROLEUM REFINER item **39.**

Air Setting Cement

Walsh Refractories Corporation's new bulletin on high temperature bonding mortar describes Mort-Airset, refractory air setting cement for laying and surfacing fire brick.

For a copy of the bulletin write Walsh Refractories Corporation, Department M-1, 4070 North First Street, St. Louis 7, Mo., referring to PETROLEUM REFINER item **40.**

The P. A. was Amazed!

In 1945, *the Purchasing Agent of a large oil refining company bought 18 Helicoid Pressure Gages —to try them out.*

In 1946, he bought 475.

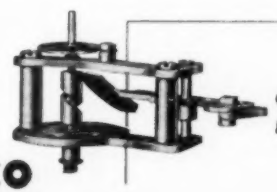
In 1947, he bought 1569.

In the first 3 quarters of 1948, he bought 1466.

But what amazed the P. A. was that with a total of 3528 Helicoid pressure gages—some of them up to 3 years old—he has had to buy *no repair parts* for replacement.

Ordinarily, for conventional spur-geared movement gages, he would have had to buy large quantities of spare movements and other spare parts.

Yes, the P. A. was amazed, and pleased. He had found out how Helicoid gages reduce maintenance costs.



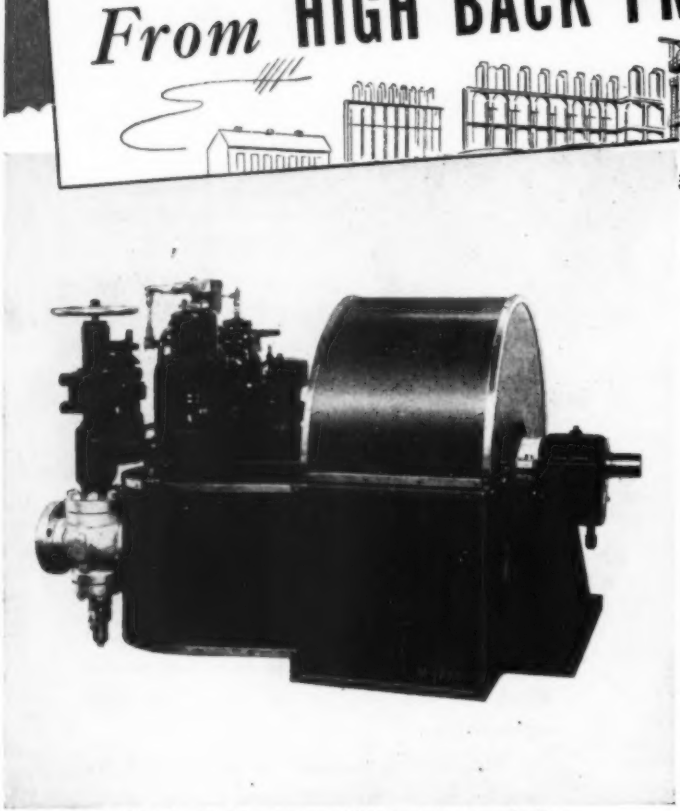
Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

TRADE MARK

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

Getting LOW COST POWER *From* HIGH BACK PRESSURE



A Worthington Single-Stage High Back Pressure Turbine for Mechanical Drive

Worthington

Topping Turbines Make Steam Do More Work

Here's how to take full advantage of the increased power-potential of high-pressure, high-temperature steam! Exhausting at pressures ranging from 100 to 250 lbs., Worthington Single-Stage High Back Pressure Turbines are specifically built for this type of operation. Features like the following tell you why:

Extra heavy, all steel casing . . . separate steam chest of alloy steel . . . centerline support compensates for casing expansion . . . high back pressure packing gland . . . water cooled or force feed lubricated bearings . . . balanced governor valve . . . horizontally split casing . . . steam and exhaust connections in lower half . . . lagged, sheet-metal-jacketed casing . . . and constant or variable speed governors, direct acting or oil relay type.

Built in sizes from 50 to 2000 hp, Worthington High Back Pressure Mechanical Drive Steam Turbines develop speeds up to 10,000 rpm. Consistently cutting fuel and maintenance costs in such drives as centrifugal compressors, pumps, fans, and blowers, they are proving to refineries everywhere that *there's more worth in Worthington*. For details, write to *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

STEAM TURBINES

TS-6

A GREAT TEAM IN STEAM

Feed Water Heaters | Multi-Stage Turbines | Boiler Feed Pumps | Turbine-Generator Sets | Single-Stage Turbines | Surface Condensers

About EQUIPMENT, SERVICE Suppliers

Robert L. Henry New Sales Engineer for Elliott Company

Robert L. Henry has joined the staff of Elliott Company, Jeannette, Pa., as a sales engineer. He will be located in the Tulsa office of the company.

Henry

Prior to this appointment Henry served as application engineer in the blower department for six years. He was particularly concerned with centrifugal blowers.

He was graduated from Ohio State University in 1942 and holds a bachelor of science degree and a master of engineering degree.

Combustion Engineering and Superheater Companies Merge

Combustion Engineering Company, Inc., and The Superheater Company has merged and future operation of the company, effective December 31, 1948, will be under the new name of Combustion Engineering-Superheater, Inc. The two companies became affiliated in 1933, but now all operations are merged under a single management. The new company will continue the world-wide activities of the present companies.

Frederic A. Schaff is chairman of the Board of Directors and Samuel G. Allen is chairman of the executive committee. President is Joseph V. Santry and Martens H. Isenberg is executive vice president. Vice president in charge of finance is Harold H. Berry and vice president and controller is George D. Ellis. Otto W. Strauss is vice president and treasurer and Wilbur H. Armacost is vice president in charge of engineering. Donald S. Walker is vice president in charge of sales and Albert C. Weigel is vice president. Vice president of the Chattanooga division is Amaziah J. Moses and vice president of the Monongahela division is John S. Skelly. Arthur Williams is vice president and Irving B. Swigart is secretary and assistant treasurer. Thomas F. Morris is assistant to the chairman and assistant secretary.

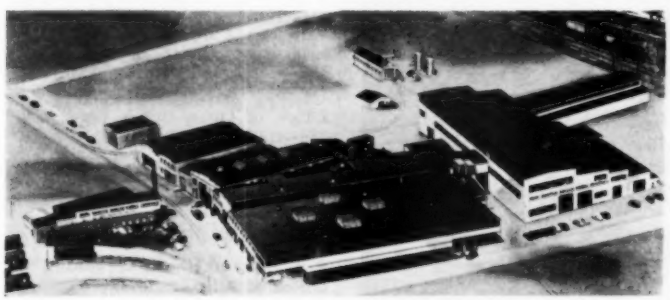
American Brake Shoe Opens New Non-Ferrous Foundry

The National Bearing Division of American Brake Shoe Company has opened a non-ferrous foundry at Meadville, Pa. Operations have been discontinued at four old plants and the company is concentrating production for the eastern area in the new foundry. When in full production, the new plant will exceed the combined productive capacities of the four old units, located at Jersey City, N. J., Pittsburgh and Meadville.

Units in the four and one-half acre tract include a two-story office and employee service building, the main foundry building and machine shop, and a heating plant.

Contractor for the new building was Ragnar Benson, Inc., and architect was

John Nooter Company Plant Expansion



Nearing completion is the $500,000 expansion program of John Nooter Boiler Works Company, St. Louis. This aerial view of the plant has been retouched to include new buildings not yet completed. The large flat-top building in the center foreground contained the original shop. At the right of the building is the new heavy fabrication shop. Wings adjoining the latter at the extreme right will house the new shop and office for the metallizing division and the new tube storage building. The expansion program will make it possible for the company to fabricate the larger types of tanks and heavier pressure vessels used by petroleum, chemical and other industries.

CONTROL

Scale and Corrosion In Water Cooled Equipment

WITH

Newly Perfected

Water Conditioning Chemicals

Recently developed applications of the newer colloids and surface-active agents in Wright Chemicals for the petroleum industry result in *improved* water conditioning—*positive* scale and corrosion control. Wright Chemicals contain 100% soluble, available chemicals—no waste or inert matter—insuring increased operating efficiency and reduced cost.

Cooling Towers . . .

Down time and replacement costs are materially reduced by effective scale and corrosion control with Wright Chemicals.

Compressors and Engine Jackets . . .

Heat transfer surfaces are kept free of scale and corrosion. Result? Greater efficiency.

Wright improved chemicals are the result of intensive study and research by men with years of experience in the development, production, application and control of water-conditioning chemicals.

Wright has no one cure-all to solve all problems. Each receives individual treatment. The Wright field engineer, who will call on you upon request, will obtain all necessary information and samples for examination in the modern Wright laboratory. Analyses are interpreted in view of supplemental information received, and recommendations made in the form of a proposal. Clients are provided with regular laboratory service as a periodic check upon conditions.

There is a Wright Field Engineer near you, anxious to help solve your scale and corrosion problems. No obligation.

Wright CHEMICALS

WRIGHT CHEMICAL CORPORATION

Specializing in Water Conditioning

GENERAL OFFICE AND LABORATORIES

615 West Lake Street Chicago 6, Ill.

Offices in Principal Cities

FOR THE LATEST STORY ON
LENAPE TYPE R AND SR MANWAY
NECKS . . . NOZZLES . . . COVERS

Write for
BULLETIN
#4-82

Standard and Special Lenape Type R and SR Manways provide a flexibility in vessel design which *is* important to all users—Bulletin #4-82 gives you visible evidence of this versatility.

Size range, style, materials, construction and application information of value are presented in complete detail.

Write today for your copy of Bulletin #4-82 and Price Schedule M-48—we feel sure you will find this data valuable reference for economical design and prompt delivery on Lenape Type R and SR Manways.

LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106
WEST CHESTER, PA.

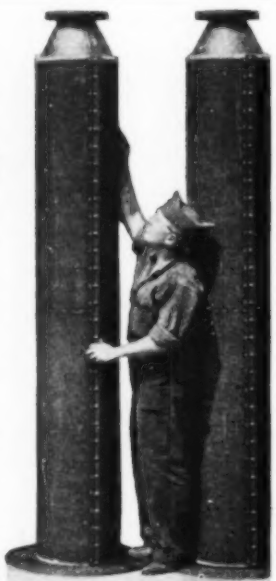
FILTER UNITS
by MULTI-METAL

THE superior construction and improved materials of Multi-Metal Filter Units give longer, more trouble-free service resulting in increased production. In addition, because of their advanced design, Multi-Metal Filter Units often can greatly improve the efficiency of existing processing installations.

The skill and experience gleaned from 35 years of intensive specialization are at your service when you place your process problems in the hands of Multi-Metal experts.

Send for free catalog and wire cloth samples, or send prints and specifications for an immediate quotation.

Always in stock—wire and filter cloth of all meshes, weaves, and metals. Order by the yard or piece.



Wire Cloth in Fabricated Units or by the roll and the cut piece

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

J. Gordon Turnbull, Inc. Engineering work was done jointly by the National Bearing Division and the Construction and Maintenance Department of American Brake.

Fox

Younger

Wolverine Appoints Three To Southwestern Division

Wolverine Tube Division of Calumet and Hecla Consolidated Copper Company has appointed A. M. Younger, formerly general manager for Atlas Mineral Products Company, as manager of southwestern sales with headquarters in Houston. Younger succeeds L. G. Fox, who has returned to the company's Detroit office to assume special assignment duties.

J. L. Young, Jr., will be in the Houston office also and with A. S. Williams, who is located in Dallas, Texas, will represent Wolverine throughout Texas, Oklahoma, Arkansas and Louisiana. Young was formerly associated with Kelly-Springfield Tire Company.

Tom Sears Is Sales Engineer For American Structural

Tom Sears has been assigned to the Dallas branch office of American Structural Products Company as Kaylo sales engineer and will handle all products of the company in the Kaylo line, including insulating roof tile, heat insulation and structural insulating block.

Sears

Sears' sales territory will consist of Texas, Oklahoma, Louisiana and the lower part of Mississippi. His business address is 404 Tower Petroleum Building, Dallas 1.

Joining American Structural, a subsidiary of Owens-Illinois Glass Company, early this year, Sears was previously associated with Allis-Chalmers Manufacturing Company. He studied at Bowling Green University and Ohio State University before receiving his electrical engineering degree in 1936 from Tri State University .

R. L. Halsted Heads Cleveland Office of Allis-Chalmers

Robert L. Halsted on December 1 became manager of the Allis-Chalmers Manufacturing Company's Cleveland district office, succeeding the late Arthur H. Wyman.

A mechanical engineering graduate of the University of Michigan, he has been manager of the Charleston office since

1942. He joined Allis-Chalmers in September, 1935, and served in the Cincinnati office for a number of years before establishing the Charleston branch. He is a member of the AIEE and the Electric League.

James Mathews, Charleston sales representative, succeeds Halsted as Charleston manager. He entered that office in February, 1946, after his discharge from the Army as a major.

Val Lobanoff Is United Pumps' Assistant Chief Engineer

Val Lobanoff has been appointed assistant chief engineer for United Centrifugal Pumps, a division of United Iron Works. His appointment is part of a long-range expansion program required to meet steadily increasing production demands. Because of his previous specialization in refinery and high pressure boiler feed pump design, he has been assigned to aid in the development of new lines of centrifugal pumps.

Lobanoff

He is a member of the American Society of Mechanical Engineers and the Pacific Coast Electrical Association, Inc.

Emil Greiner Moves Into New Nine-Story Modern Building

Emil Greiner Company, manufacturers and distributors of scientific and industrial glassware, laboratory and chemical supplies, has recently moved to its new nine-story building at 20-26 North Moore Street, New York 13.

The top floor of the building contains a complete machine shop. The glass blowing shop is situated on the eighth floor. All engraving, volumetric, hydrometer and thermometer work is done on the seventh floor. Stock is located on the third, fourth, fifth and sixth floors with offices on the second floor. Shipping, receiving and counter sales are executed from the first floor.

Norman Michels Named Manager For Laclede-Christy Company

Norman C. Michels has been appointed manager of operations of Laclede-Christy Company and its subsidiaries. He will have complete charge of all manufacturing and mining operations. Prior to this advancement, Michels was chief engineer for the company.

Formerly he was a member of the engineering staff of Carnegie-Illinois Steel Company. He is a graduate of Purdue University and did graduate work at Massachusetts Institute of Technology.

Babcock Sales Division Names W. H. Buley, J. A. Anderson

William H. Buley has been appointed manager of stainless sales of The Babcock and Wilcox Tube Company, Beaver Falls, Pa. At the same time James A. Anderson was named assistant general sales manager of the company. Both will be located in the general offices of the company at Beaver Falls.

Buley, a University of Wisconsin graduate, was with Sinclair Refining

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150	300	600	1200
163	313	650	1250
175	325	700	1300
188	338	750	1350
200	350	800	1400
213	363	850	1450
225	375	900	1500
238	388	950	1550
250	400	1000	1600
263	450	1050	

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Company and Globe Steel Tubes Company for 11 years, joining the sales department of Babcock & Wilcox Tube Company in 1939. Recently he has been manager of the general sales office.

Anderson is a M.E. graduate (1932) from Case Institute of Technology, was with the steel and tubes division of Republic Steel Corporation for nine years and joined B. & W. Tube Company's New York sales office in 1941. He has been assistant manager there since 1944.

Foley Dana

Industrial Process Appoints Chicago, St. Louis Agents

Industrial Process Engineers, West New York, N. J., has appointed A. J. Foley and A. J. Foley Company as its Chicago territory representatives, succeeding Raymond J. Selwyn of Selwyn Engineering Company. The new sales office is at 7309 East End Avenue, Chicago. Territory includes Chicago, the northern part of Illinois and northwestern Indiana.

James P. Dana of Midwest Equipment and Supply Company will represent the company in the St. Louis territory. This new office is Suite 713, Ambassador Building, 411 North Seventh Street, St. Louis 1, Mo. The territory covers the eastern half of Missouri, the southern half of Illinois and the western part of Kentucky.

Plant Equipment Company, 946 Betts Street, Cincinnati 14, has been appointed representative for Industrial Process in the Cincinnati territory to cover Cincinnati, southwestern Ohio, southern Indiana, eastern Kentucky, eastern Tennessee and southern West Virginia.

In the Pittsburgh and Cleveland districts, the company will be represented by John B. Moorehead of John B. Moorehead Company, 335 Fifth Avenue, Pittsburgh 25. His territory includes western Pennsylvania, eastern Ohio, northern West Virginia and western Maryland.

AMCA Chooses Officers, Directors at Annual Meeting

Peter G. Dennison was elected president of the American Metallizing Contractors Association at its annual meeting in Tulsa on December 2-4, 1948. Vice president is K. B. Smith. Walter B. Meyer was re-elected secretary-treasurer. Nine members were elected to the board of directors.

President and founder of The Metal Spraying Corporation, Dennison developed the "flash coating method" for improving the bonding of white metal coatings to large area surfaces. The "Dennison Method of Shaft Preparation," also developed by him, is a method for bonding hard metal coatings to

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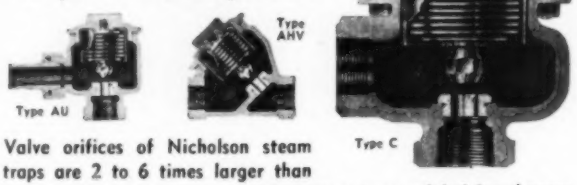

Valve orifices of Nicholson steam traps are 2 to 6 times larger than in average traps, minimizing chances of plugging. And, valves being at the bottom, dirt drops out by gravity. This ability to self-clean is one of the features resulting in the unequalled discharge capacity of Nicholson traps. 5 types for every industrial application; size ¼" to 2"; press. to 225 lbs. Test trap gladly sent. BULLETIN 1047.

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cylindrical surfaces. It reduces the human element to a minimum in preparation for metallizing.

Smith is vice president and general manager of Dix Engineering Company, Inc. Meyer is manager of the metallizing division of John Nooter Boiler Works Company.

The next meeting of the association will be held in Milwaukee, Wis., on May 5-7, 1949.

Frank Settle Is Field Sales Engineer for Schaub Company

Fred H. Schaub Engineering Company, Inc., Chicago, has appointed Frank T. Settle as field sales manager for all products and equipment of the company.

Settle

For the past ten years, he has been associated with General Tire and Rubber Company, Akron, Ohio. During this time he served as a Kraft engineer and as sales manager in the Rocky Mountain division.

Settle is a graduate of Columbia University, New York City.

Wheelco Opens Houston Office

Wheelco Instruments Company, Chicago, has announced the opening of a new district office at 2204 Fannin Street, Houston 5. The new office, under the direction of George Hatfield, formerly of the company's Chicago sales office, will handle sales and service for the states of Texas, Louisiana and New Mexico.

Taylor Forge Work Appoints T. J. Lingle Western Manager

Taylor Forge & Pipe Works, Chicago, has appointed Thomas J. Lingle as western division manager in charge of manufacturing operations at its new Fontana, Calif., plant. He also will direct West Coast sales.

Lingle

Formerly he was associated with C. F. Braun Company of Alhambra, Calif. Since 1946 Lingle has operated his own valve and fittings business in Alhambra.

The Fontana plant of Taylor Forge already has begun production of spiral pipe. Forging operations will begin soon.

Rittling Names John Barnes Vice President for Sales

John C. Barnes has been appointed vice president for sales in the eastern division of The Rittling Corporation, Buffalo, N. Y. His offices will be located in Philadelphia.

Recently Barnes resigned as vice pres-

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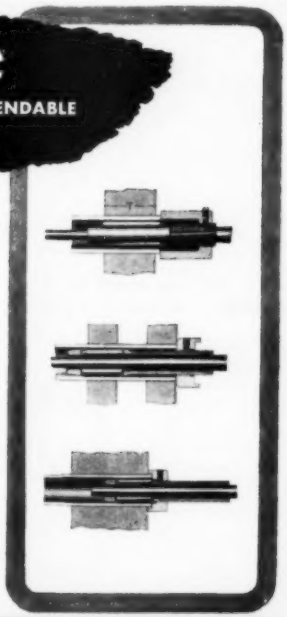

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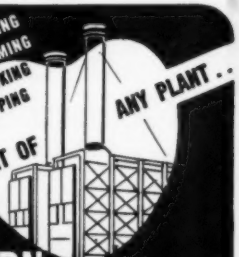

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ident for sales for National Radiator Company. Formerly he was sales engineer and branch manager of the company's Philadelphia office. Before becoming associated with National he was associated with the plumbing and heating division of Montgomery Ward.

J. W. Kelley Named Division Sales Manager for Patterson

Joseph W. Kelly has been appointed division sales manager of the special equipment division of The Patterson Foundry and Machine Company, East Liverpool, Ohio. He will be in charge of the sale of specially designed chemical and process apparatus. His headquarters will be in East Liverpool.

Kelley

Before joining Patterson Kelley was assistant sales manager of Goslin-Birmingham Company, Birmingham, Ala. He is a graduate of the University of Alabama, taking his degree in chemical engineering.

Gordon Davisson Engineering Representative for Young

Gordon Davisson has joined Young Radiator Company, Racine, Wis., as an engineering representative to be primarily concerned with field work. Prior to this appointment he was chief sales engineer for Linear, Inc.

Following his graduation from the Illinois Institute of Technology with a bachelor of science degree in mechanical engineering, Davisson joined International Harvester Company, working at the West Pullman Works and in the refrigeration and industrial engineering and construction departments.

A member of the Army Air Forces he was on the working committee of the Aeronautical Board and had charge of a program to standardize hydraulic equipment for Army and Navy aircraft.

Davisson is a member of the Society of Automotive Engineers, the Air Force Reserve and holds a private pilot's license.

W. T. Cushing Made Sales Manager for National Supply

W. T. Cushing, Jr., has been appointed division sales manager of a new division sales department just organized at Casper, Wyoming, by The National Supply Company, Pittsburgh, to integrate and expand operations in the Northwest area of the United States and Western Canada. He has been Northwestern division engineer for the company at Casper since last year.

Cushing

New members of the staff at Casper are R. D. Stottlemyer, division engineer, formerly of the plant products division in Houston, Texas; and K. L. Thompson, who is being transferred from the company's purchasing department in Toledo, Ohio.

Sparkler Chooses Agent

Sparkler Manufacturing Company, Mundelein, Ill., has named Gulf Engineers, Inc., as factory sales representatives for the Sparkler line of pressure filters in Texas, southeastern New Mexico and southwestern Louisiana.

Gulf Engineers, Inc., maintains headquarters in Houston and has a branch in Dallas.

Young Representative Named

National Requirements Service, Dayton, Ohio, has been added to the list of Young Radiator Company's representatives for specific representation at Wright-Patterson Air Force Base, Dayton. William W. Bentley, Jr., is president. Long associated with the field of aviation, the company will offer engi-

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neering and sales service of Young heat transfer products and facilities to the Air Forces.

Irving Cole Heads Technical Division of Attapulgus Clay

Irving A. Cole has been appointed manager of the technical division of Attapulgus Clay Company and has assumed his new duties in the company's laboratories at Camden, N. J.

Cole

Before his recent appointment Cole was engaged in the sales department and specialized in the technical aspects of the development of new fullers earth and bauxite products. Prior to joining Attapulgus in 1946, he was associated with the research and development department of The Atlantic Refining Company.

A 1943 graduate of Cornell University, Cole holds a bachelor degree in chemical engineering.

Dr. G. Thiessen Is Technical Advisor for Koppers Division

Dr. Gilbert Thiessen, formerly development manager of the chemical division of Koppers Company, Inc., has been named technical advisor for that division. He will coordinate and advise on technical matters relating to the development, sale, and use of products, produced or to be produced in plants of the division.

Dr. Thiessen received his Ph. D. degree from the University of Pittsburgh in 1930, has been with Koppers continuously since 1937 and since 1946 has served as manager of the development section of the chemical division.

Chiksan Names G. R. Winder Vice President, Sales Head

G. R. Winder has been named vice president and sales manager of Chiksan Company, Boca, Calif., effective January 1, 1949. He will also be vice president and sales manager of Chiksan Export Company.

Transferring from Well Equipment Manufacturing Corporation, Houston, a Chiksan subsidiary, he has served with the company in the same capacity for the past three years. The new assignment brings him back to Chiksan headquarters where he was formerly a member of the sales department.

T. T. Word, Jr., assistant sales manager of Well Equipment, becomes sales manager, succeeding Winder.

Jessop Appoints J. D. Freeze New York Sales Manager

Jonathan D. Freeze has been appointed district sales manager of the New York territory for Jessop Steel Company, with offices at 30 Church Street, New York.

Formerly associated with Armco International Corporation, he served both here and abroad. Most recently he was Chicago representative for Fritz W. Glitsch and Sons, Inc. Freeze has also been a sales engineer for U. S. Steel Export Company and assistant manager of the tin plate division of Crucible Steel Company.

American Brake Appoints N. G. Belury Division Official

N. George Belury has been appointed president of the engineered castings division of American Brake Shoe Company, Rochester, N. Y.

Associated with Brake Shoe since graduating from Purdue University in 1937, he was formerly division vice president. He also has served in various sales capacities with engineered castings including that of sales manager. Belury is a member of the Gray Iron Founders Association and the American Society of Mechanical Engineers.

Hammond Names Faville-LeVally

Faville-LeVally Corporation, Chicago 3, has been appointed exclusive representative in Southern Michigan for Hammond Iron Works, Warren, Pa., and Port Neches, Texas.

Rockwell Moves Two Divisions

Rockwell Manufacturing Company has announced that its Pittsburgh Equitable Meter and Nordstrom Valve divisions will be located at 25 Beale Street, San Francisco 5, and 1102 Delano Street, Houston 1.

Moule Appointed Sales Manager

Thomas B. Moule, formerly assistant director of sales, has been appointed sales manager of Plomb Tool Company, Los Angeles. Since joining the company in 1944, he has supervised many sales and merchandising activities. For five years following his graduation from the University of Michigan, Moule was advertising and sales promotion manager for Ex-Cello Corporation. He then served as sales and advertising counsel for four years while account executive and new business manager for R. L. Wolfe & Associates. For three years he was with The Aviation Corporation before coming to Plomb.

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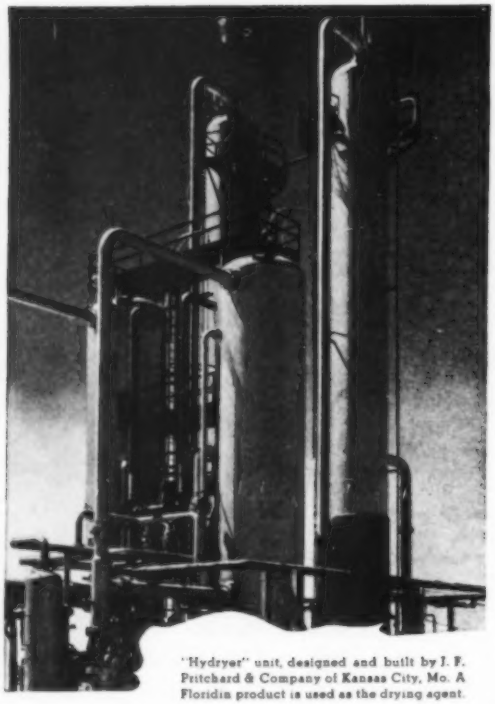

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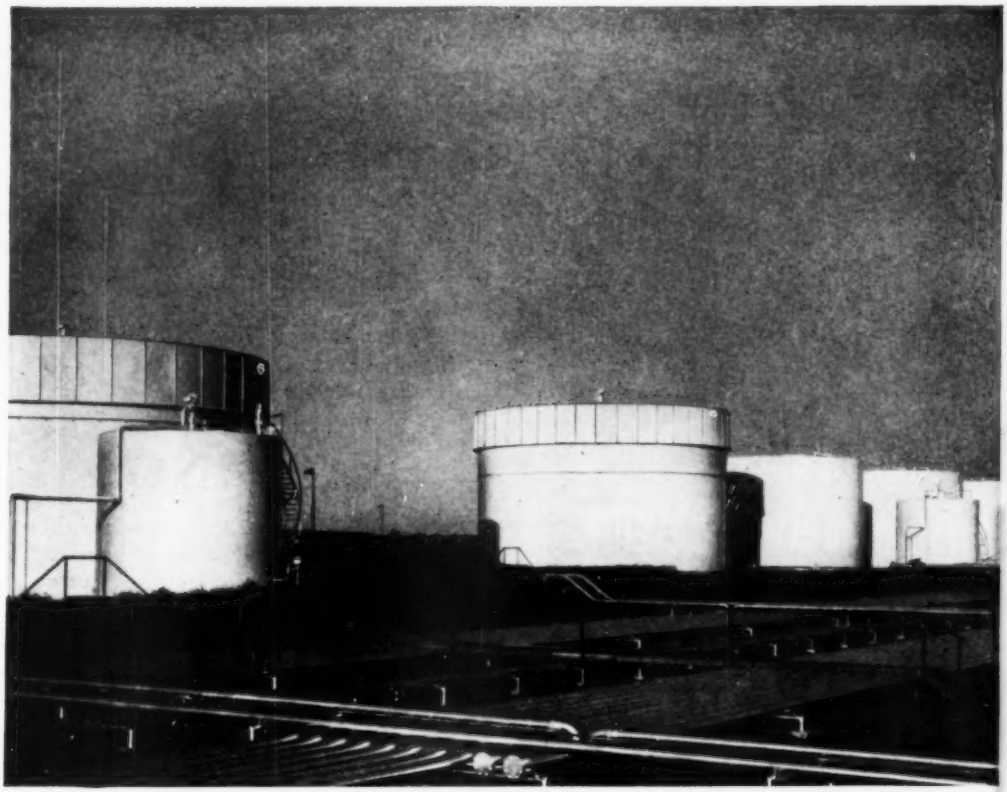

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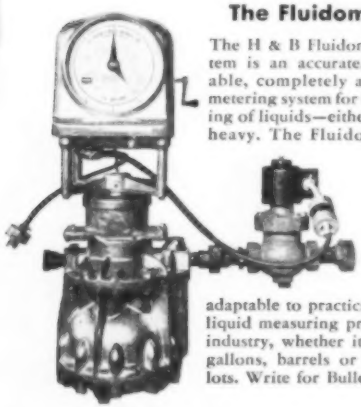

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RUGGED CONSTRUCTION . . . Elimination of delicate components, shock mounting of tubes, and welded aluminum case make the instrument very suitable for field use.

INCREASED THICKNESS RANGE . . . Steel thickness from 1/16" to 12" is read on the direct reading conversion scale. Many other materials may be tested.

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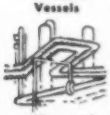
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Design improvements incorporated in the AUDIGAGE Model FMSS-5 are based on two years of practical experience in the manufacture of ultrasonic thickness gages for over 100 refineries and chemical plants. AUDIGAGE thickness testing has eliminated a large percentage of "drilling and plugging". Accurate and reliable surveys of equipment in and out of service are obtained rapidly and accurately by testing from one side. Use of the ultrasonic resonance method makes the accuracy of the readings independent of coke or scale deposits and liquids inside the vessels. For a given number of man-hours devoted to inspection, many more points can be checked, resulting in lower inspection costs, shorter shutdown periods, and greater plant safety.

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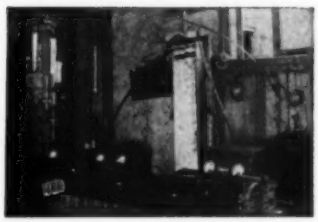
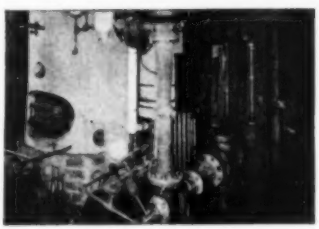
What's *behind* a CROLL-REYNOLDS Evactor?

1

Instruments in the CR laboratory set up for measuring extremely high vacuum.



The production of Evactors is no routine operation at the Croll-Reynolds plant. Although CR engineers have over thirty years of industrial vacuum experience to guide them, the Croll-Reynolds testing and development department is one of the important units of the company. Development work is constantly under way to improve the efficiency of Croll-Reynolds Evactors wherever it is possible. It is this never-ending research and development which give CR Evactors their exceptional efficiency.



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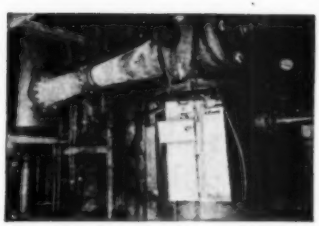
Special boiler in the CR pilot plant for providing unusual conditions of high pressure steam or superheat (or both) to duplicate the working conditions in customers' plants.

3

A 30-inch CR Booster Evactor on test in a CR shop.



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Conservatively rated, precision-made CMH Expansion Joints offer new highs in dependability and trouble-free service. Compact corrugated assemblies cannot leak; there is no maintenance. Just install CMH Expansion Joints and forget about them.

CMH Expansion Joints are available in two types—Controlled-Flexing Joints with precision-mated control rings for higher pressures; Free-Flexing Joints for lower pressures. Both types are furnished in stainless steel or copper. Special expansion joints can be furnished for unusually high pressure ratings.

On your next job, whether it's a new installation or replacement of obsolete equipment, specify CMH Expansion Joints. Bulletin EJ-47, available on request, incorporates data for guidance in selecting the CMH Expansion Joints for your requirements. Both standard flanges and welded ends are furnished.

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"the science of FLEXONICS . . ."the controlled bending of thin metals for use under varying conditions of temperature, pressure, vibration and corrosion". . . is exemplified in the basic products of Chicago Metal Hose Corporation.

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CHICAGO METAL HOSE CORPORATION

Expansion Joint Division • Maywood, Illinois

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Pop's on the spot. There are no parts left over and still the pygmy power plant won't produce a single putt or puff. It won't even give a hoot. Believe it or not, water "treatment" will help . . . a cupful or two of any kind of water in that empty boiler.

But it takes more than "any kind of water" to produce good results in a full-size operation. Whether used for power, process or cooling, water frequently needs correction. Otherwise scale, corrosion and carryover will send efficiency down, operating costs up. Water and steam-handling equipment will have a short and unhappy life.

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An informative illustrated booklet discusses these problems and their solutions. Write for your copy today.

BA-131

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Yarways are suitable for all pressures without change of valve or seat. Simplicity of construction (only one moving part) minimizes maintenance. Also, initial cost is low.

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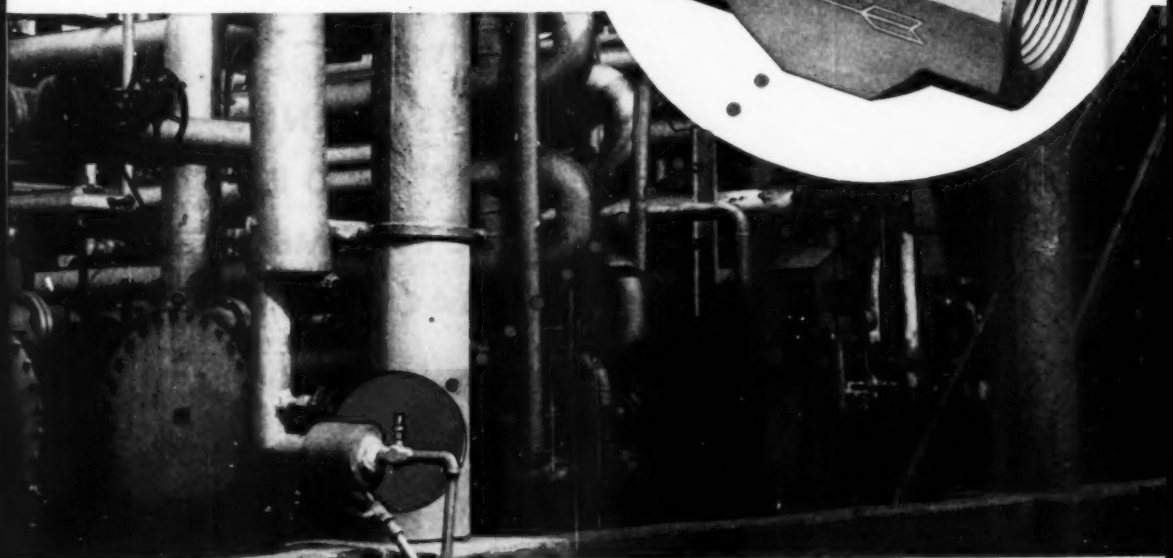

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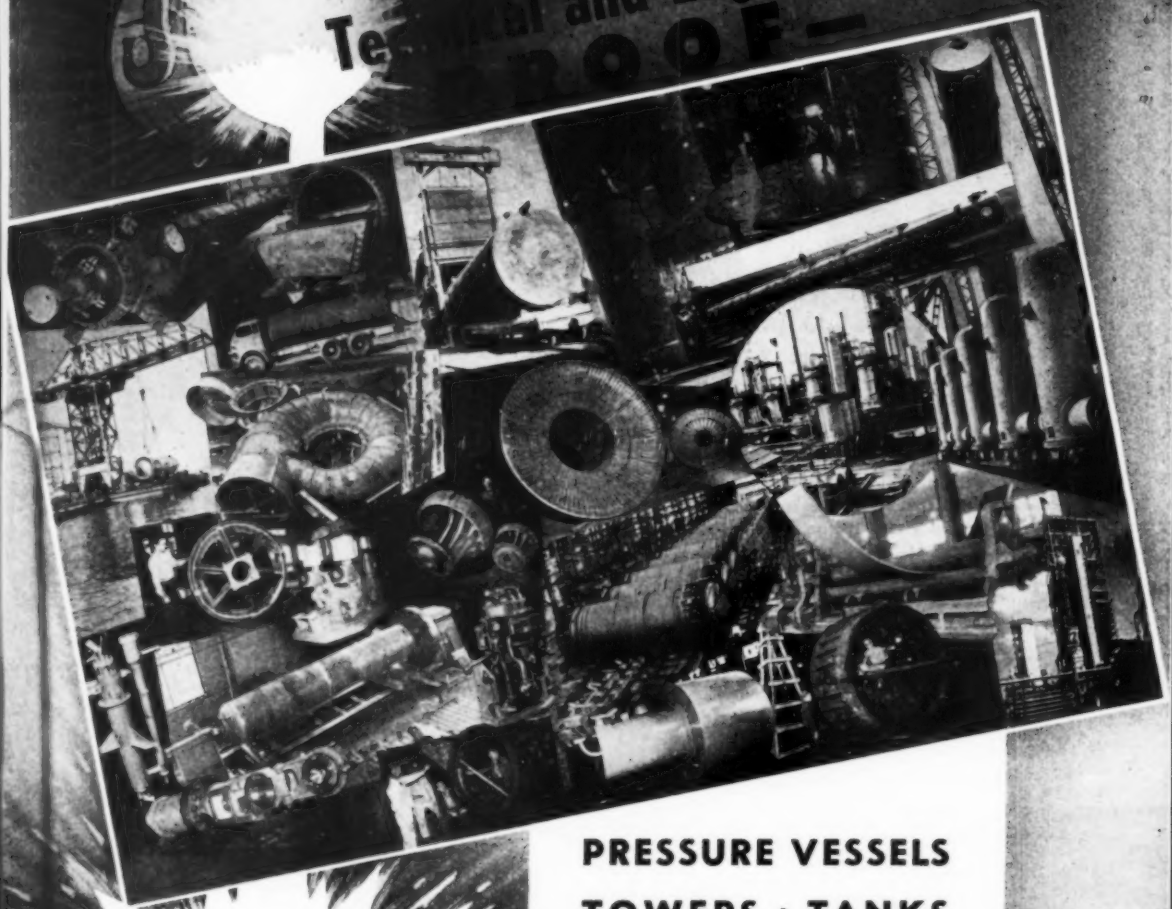

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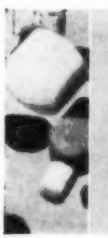

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ENGINEERING PROBLEMS IN AGITATION

PART OF A CONTINUING PROGRAM OF ENGINEERING BY MIXING EQUIPMENT CO., FOR THE ADVANCEMENT OF AGITATION

TOP-ENTERING
PORTABLES
SIDE-ENTERING

How much should a gear shaft flex between bearings?

.005? .020? .0002?

TOP ENTERING MIXERS

LABORATORY MIXERS

PORTABLE MIXERS

SIDE ENTERING MIXERS

EXPLANATION: This question applies, of course, to precision speed reducers used for agitator drives. As you know, agitator service is probably the only service where users try to get away with rigid coupling of the load to the reducer. In all other services, manufacturers insist on connecting the load by means of a flexible coupling. The illustration above shows in an exaggerated form what happens when the load is direct connected.

Gear shaft deflection of more than .0005 will shorten the life of the reducer. The larger the deflection the more serious the effect. It may also cause early failure of both lower bearings and gears.

COMPROMISE ANSWERS: Three very poor compromises can be made: (1) leave the bearing spacing the same and beef up the lower bearing to stand the gaff; (2) increase the bearing spacing by means of an extension or steeple, keeping the gear below the point of maximum flexure; (3) add another bearing below the reducer. The fact that these modifications are made on reducers of reliable manufacture emphasizes the need for a rugged agitator drive, without expensive stop-gap modification.

Such modifications increase the investment in the reducer alone and step up the consequent shut-down and loss when the reducer fails or parts are required. The occasional satisfactory use of such design, accruing from a happy combination of light duty, flexible agitator shaft, etc., cannot justify their general applications in the face of proven engineering practice: ***"Connect a speed reducer to the load with a flexible coupling."***

NEW W SERIES

SOLUTION: Mixco solves this problem with a low head room, shock proof coupling and simple reducer design. Complete details cannot be given in this limited space, but you can get them in Bulletin B-78. Send for your copy. It's good "reducer insurance" against shut-downs.

If you would like to have some phase of agitation similarly discussed, write us your suggestion. You will receive a personal reply. Write us also about your regular requirements in fluid agitation. Our wealth of background and experience gets results for you.

With Independent Bearings for the Agitator Shaft

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For open and closed tanks

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- ☐ B-75—Portable Mixers (Electric and Air Driven)
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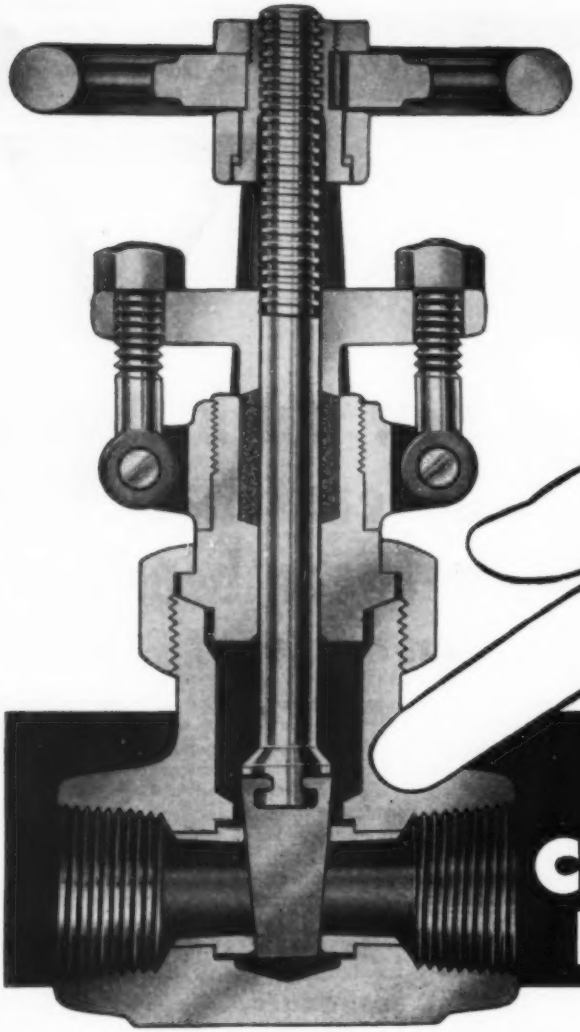

Super-hardened Discs

mean years of extra wear

CHAPMAN LIST 960

LONG WEAR is built right into this sturdy Chapman gate valve. Stem, seat rings and plugs, for instance, are made of stainless steel for maximum resistance to corrosion. And for maximum wear resistance discs are not just hardened *but are super-hardened by Malcomizing.*

But that's only part of the story. The body is made of forged steel for extra toughness. And you can repack these Chapman valves under full pressure. These features all add up to longer endurance . . . years more of trouble-free service.

Made in sizes from ¼" to 2" — carbon steel for pressures to 800 pounds and alloy steel for working pressures up to 1000 pounds at 750°F. For higher pressures, specify List 990.

THE CHAPMAN VALVE MFG. CO.

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Let Patterson efficiency in equipment design and performance produce BETTER PROFITS in your process operations.

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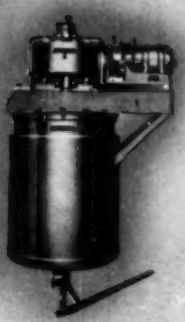

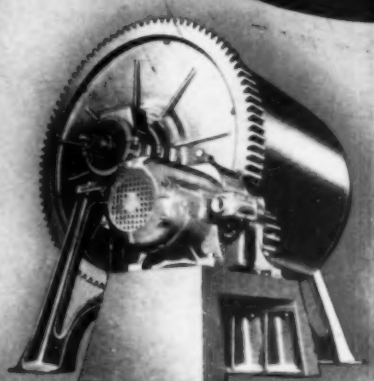

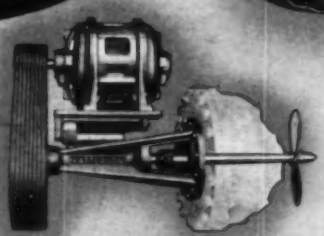

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